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REFERENCE 14

Ecology & Environment Inc., September 1, 2005, *Black Butte Mine, Site-Specific Sampling Plan, TDD: 05-04-0005,* prepared for the U.S. Environmental Protection Agency, 211 pages.

REFERENCE 2

Black Butte Mine
Site-Specific Sampling Plan

TDD: 05-04-0005

Ecology and Environment, Inc.
Contract: 68-S0-01-01

September 1, 2005

Region 10

START-2

Superfund Technical Assessment and Response Team

START-2 Sample Numbers: 05080101 through 05080200

SITE-SPECIFIC SAMPLING PLAN (SSSP) FOR REMOVAL PROGRAM SITES

Project Name: Black Butte Mine
Technical Direction Document (TDD) Number: 05-04-0005
Contract Number: 68-S0-01-01

APPROVALS			
Name	**Title**	**Signature**	**Date**
Marc Callaghan	On-Scene Coordinator (OSC)	[signature]	Sept 6, 2005
Erin Lynch	START-2 Project Manager	[signature]	9/6/05
Mark Woodke	START-2 Quality Assurance Officer	[signature]	9-6-05

This SSSP is prepared and used in conjunction with the Generic Superfund Technical Assessment and Response Team (START)-2 Quality Assurance Project Plan (QAPP), January 2003, for collecting samples during Removal Program (RP) projects. Refer to the Generic START-2 QAPP for additional details relating to the SSSP.

Additional Personnel and Affiliations involved in the project

U. S. Environmental Protection Agency (EPA) OSC			
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Physical Description and Contact Information

Site Name	Black Butte Mine (See Figure 1-1; Site Location Map)	
Site Location	Address: 10 miles south of Cottage Grove	
	Lane County, Oregon	
	Latitude: 43° 34' 42" North	Longitude: 123° 03' 58" West
Property size	Acres: To be determined	
Site Contact	Name: Robert A Smejkel, P.C.	Phone Number: (541) 345-3330
Site Owner	Name: Land and Timber Company	Phone Number:
Site Operator	Name: Michael Pooler	Phone Number: (541) 942-1008
Nearest Residents	Distance: On site	Direction: Northwestern most corner
Primary land uses surrounding the site	Land use in the vicinity is primarily rural residential and recreational.	

Years of operation	From: Late 1890s	To: Late 1960s

The Data Quality Objective process will be used to determine all sample locations; this process is further described in the Generic START-2 QAPP.

Site Location and Description

The Black Butte Mine (BBM) site is a former mercury mine located in southern Lane County, in the Coast Fork Willamette River basin, approximately 10 miles south of Cottage Grove, Oregon off London Road (Figure 1-1). The site is located on the northeast flank of Black Butte. The elevation of the site is between approximately 1,080 and 2,420 feet above sea level.

The primary features of the site include mine waste piles; a former mill structure containing a rotary kiln, mercury condenser, and ore storage/crushing equipment (new furnace area); another mill and furnace area (old ore furnace); several old dilapidated buildings; a system of unimproved roads; and some partially caved-in mine adits (Figure 1-2).

Historical and Background Information

The BBM has been identified in recent Total Maximum Daily Load (TMDL) work as a significant contributor of mercury to sediment and fish tissue in Cottage Grove Reservoir. Cottage Grove Reservoir, and the main stem of the Willamette River, the nation's 13th largest watershed, are water quality limited for mercury, and the Oregon Department of Human Services has issued health advisories to limit consumption of fish due to elevated mercury concentrations in fish tissue. The Willamette River is also home to several threatened or endangered species.

The BBM was first operated in the late 1890s. The mine operated intermittently through the late 1960s, with peak production occurring during the period from 1927 to 1943. Between the years 1900 and 1957, a total of 16,904 flasks of elemental mercury were produced at the mine (1 flask equals 76 pounds). According to Brooks (1971), the original operator/owner of the mine was the Quicksilver Mining Company, which managed the operations until 1909 when the mine was closed because of depressed mercury prices. The mine was re-opened in 1916 by a New York company under the management of Earl B. Crane. In 1927, the mine was purchased by the Quicksilver Syndicate. Mining operations continued until 1943 under this ownership, when mercury prices again forced closure of the mine. In 1956, the mine was again re-opened under lease to the Mercury and Chemical Corporation of New York (Brooks 1971). The site is currently owned by the Land and Timber Company, 696 Country Club Road, Eugene, Oregon 97401.

Mercury-bearing ore was extracted from underground workings and transported to the surface via light rail cars. The primary ore mineral at the site was cinnabar, a mercuric sulfide. Minor amounts of metacinnabar (another form of mercuric sulfide) and elemental mercury were also present in the ore (Brooks 1971). Ore was crushed in preparation for processing. The crushed ore was roasted in a kiln to volatilize the mercury. The resulting mercury vapor was then condensed and liquid mercury bottled for shipment. A flotation process, in which crushed ore is processed to concentrate the ore mineral(s) prior to roasting, was reportedly used between 1916 and 1919 (Brooks 1971). Two ore processing areas have been identified as described above, the new furnace area and the old ore furnace. The dates of operations of the different areas are not known.

Processed ore from the ore milling operations were deposited downhill, mainly toward the north, from the mill areas. Ore was reportedly re-processed in 1943 (Brooks 1971), apparently because the roasting prior to 1943 left appreciable quantities of mercury behind in the waste.

Previous Investigations

Prior to a Preliminary Assessment (PA) conducted by the Oregon Department of Environmental Quality (DEQ) in 1996, under a cooperative agreement with EPA Region 10, no other formal investigation has been identified at the site. Several organizations however, had conducted sampling efforts in the vicinity of the site. The following lists these earlier efforts as well as the more formal investigations that have occurred at or near the Black Butte Mine site:

- Limited sediment and tissue sampling: Oregon State University, Department of Fisheries and Wildlife (1991). This study compared samples from three Oregon reservoirs. Samples from Cottage Grove Reservoir included tissue samples from five largemouth bass and several sediment samples. Muscle tissue from the oldest two fish showed mercury concentrations of 1.49 and 1.79 parts per million (ppm). Mercury concentrations in sediment samples averaged 0.84 micrograms per kilogram (μg/g), dry weight.
- Tissue analysis on an addled egg from a bald eagle's nest: U.S. Fish and Wildlife Service (1992). The addled egg was analyzed for trace elements and mercury (2.9 μg/g, dry weight and 0.76 μg/g, wet weight). These concentrations are significantly higher than nationally reported mercury levels for bald eagle eggs.
- Limited sediment and tissue analysis: U.S. Geological Survey (1993). Site related data were generated as part of a periodic state-wide sampling. Samples were collected from three locations in the vicinity of Black Butte Mine.
- More extensive sediment sampling: Oregon State University Department of Fisheries and Wildlife (1992 and 1994). Additional sampling completed in 1992 detailed apparent elevated levels of methylmercury in fish tissue in Cottage Grove Reservoir. The tissue concentrations approached or exceeded the U.S. Food and Drug Administrations limit for human consumption of 1 part per million (ppm) for commercially caught fish. In 1994, soil samples were collected from near BBM and sediment samples were collected from Cottage Grove Reservoir and its tributaries. Results of surface soil sampling near the rotary kiln indicated the presence of mercury at concentrations of 350 milligrams per kilogram (mg/kg). Mercury was also detected in sediments in Dennis and Garoutte Creeks downstream of BBM with concentrations up to 267 mg/kg. This data appeared to support the conclusion that elevated mercury levels in sediments

can be traced to the Dennis Creek drainage, and may result from off-site transport of mercury from the BBM.

- Preliminary Assessment: Oregon DEQ (1996). The PA was conducted to identify potential public health and environmental threats related to the site. The scope of the investigation included a review of available file information, interviews, a target survey, and an on-site reconnaissance inspection. No new sampling was conducted for this assessment.
- Site Inspection (SI): Ecology and Environment, Inc. *for EPA Region 10* (1999). The SI was conducted to: document a threat or potential threat to public health or the environment posed by the site; identify if a potential emergency situation exists that may require an immediate response; assess the eligibility of the site for National Priorities List inclusion; and document presence or absence of uncontained or uncontrolled hazardous substances on site.
  - The SI involved the collection of samples from potential hazardous substance sources at the mine and from target areas potentially impacted through contaminant migration from on-site sources. Sources identified for the SI included mine tailings, the former mill/rotary kiln (referred to as the new furnace area), and the mine adit. All of the sources for the SI contained at least one hazardous substance at significant concentrations. A total of 52 samples (excluding QC samples) were collected for the SI. Sample locations included multiple locations at the on-site sources, Dennis Creek, Garoutte Creek downstream of its confluence with Dennis Creek, and nearby springs and domestic wells used for drinking water. Samples were analyzed for target analyte list (TAL) inorganic elements at EPA's Manchester Laboratory.
  - Mercury, found in only one sample, and arsenic detected in seven samples, were the only contaminants detected at significant concentrations in the mine tailings. The former mill/rotary kiln soils contain 10 contaminants at significant concentrations, most notably mercury, which ranged in concentration from 91.9 mg/kg to 54,300 mg/kg, and arsenic which ranged in concentration from 114 mg/kg to 952 mg/kg.
  - Groundwater samples collected from nearby springs and domestic wells contained elevated concentrations of inorganic elements that were also detected at significant concentrations in the on-site sources. Arsenic was detected above the federal maximum contaminant levels (MCLs) for drinking water in three of the domestic wells sampled for the SI. Mercury was not detected in either of the spring samples or any of the domestic well samples.
  - Although surface water sample results from Dennis Creek and Garoutte Creek did not strongly indicate a release of contaminants to the water column, the migration of contaminants from tailings to the creek was confirmed by elevated concentrations of mercury in two sediment samples collected downstream of the "lower" tailings pile. However, no elevated contaminant concentrations were observed farther downstream in Garoutte Creek that could be attributed to releases from the mine sources.

- A one time sampling of surface water and sediment from the Dennis Creek adit indicated that significant concentrations of several inorganic elements are present in both the surface water and sediment. Arsenic was not detected in either surface water or sediment however, mercury was detected in sediment (11.5 mg/kg).

- Sources and Chronology of Mercury Contamination in Cottage Grove Reservoir *for U.S. Army Corps of Engineers, Portland, Oregon*: L.R. Curtis, Oregon State University (May 20, 2003). The objective of this study was to assess a potential point source for mercury (BBM) and determine the distribution of mercury contamination in Cottage Grove Reservoir and its tributary streams. This study examined mercury contamination in soils of BBM (the suspected point source) and downgradient tributary stream and reservoir sediments. Reservoir sediment core stratigraphy samples, from sediment cores collected in 1995 and 2002, were also analyzed for mercury and assessed for how contaminant loading changed over time. Mercury distribution in tributary stream sediments and reservoir sediment core stratigraphy supports the conclusion that BBM is a point source of mercury contamination to the Cottage Grove Reservoir. Mercury concentrations in largemouth bass were found to exceed State and Federal Action Limits.
- Reconnaissance Soil Sampling at the Black Butte Mine *for DEQ:* L.R. Curtis, Oregon State University (August 9, 2004). Ninety-nine composite surface soil samples were collected from an area forming a 1.5 mile radius circle centered on BBM. All 99 soil samples were analyzed for total mercury concentrations. In addition, mercury speciation analysis was conducted on ten of the soil samples. Results of the analysis for total mercury indicated that soils in the immediate vicinity of furnace areas were heavily contaminated with mercury. Total mercury in soils near the old ore furnace ranged from 1,120 to 2,090 μg/g. Total mercury in soils near the new furnace area ranged from 41 to 727 μg/g. Results of the sequential selective extraction analysis were interpreted to indicate that most of the mercury in soil near the kilns was cinnabar. Some strong-complexed and organo-complexed mercury were also present in these soils. Processed ore pile samples contained mostly strong-complexed and organo-complexed mercury and lower percentages of cinnabar, a mercuric sulfide. More mobile forms were interpreted to have leached away.

As a result of these investigations/observations, five main areas of contamination have been identified at the BBM site. These five main areas compose the decision areas present at the site (Figure 1-2):

- Main Waste/Tailings Pile;
- Old Ore Furnace;
- New Furnace Area;
- Other areas of potential contamination (including adits and associated waste rock, seeps); and

- Sediment and water in Furnace Creek, Dennis Creek (and Garoutte Creek).

The contaminants of concern include mercury and arsenic. The physical/chemical threats to the population at risk are exposure to soils at BBM and ingestion of fish containing mercury. Mercury has been detected in samples from the Main Waste/Tailings Pile, Old Ore Furnace, New Furnace Area, and in sediment from Furnace Creek and Dennis Creek. The following is an anticipated sampling constraint: heavy brush and small trees in the Old Ore Furnace area and surrounding waste pile. The proposed schedule of project work follows:

Activity	Estimated Start Date	Estimated Completion Date	Comments
SSSP Review/Approval [a]	August 10, 2005	August 19, 2005	
Mobilize to Site	September 6, 2005		
Sample Collection	September 15, 2005		
Laboratory Sample Receipt	September 16, 2005		
Laboratory Analysis	September 19, 2005	October 17, 2005	
Data Validation	October 17, 2005	October 24, 2005	
Draft Report	November 28, 2005		
Target Completion Date	December 9, 2005		

[a] For emergency response projects, the SSSP may be submitted within 30 days after the response date. For projects involving the EPA Region 10 laboratory, the EPA RSCC must review and approve the SSSP prior to sample collection activities.

Conceptual Site Model

Figure 1-2 shows the site features including the Main Waste/Tailings Pile, Old Ore Furnace, New Furnace Area, other potential areas of contamination, and sediment and surface water from Furnace Creek and Dennis Creek.

The Main Waste/Tailings Pile is estimated to contain 300,000 cubic yards of material. These materials are bordered on the north by Dennis Creek. In addition, waste materials are present in the New Furnace Area and a waste/tailings pile is present in the Old Ore Furnace area. Mine waste/tailings in the Old Ore Furnace area are bordered by Furnace Creek. Evidence suggests that significant volumes of mine waste/tailings have eroded into Furnace Creek.

Mine waste/tailings were deposited below the ore processing areas over the course of approximately seventy years of intermittent mining operations. These tailings are expected to be heterogeneous in terms of mineral and chemical composition, as well as grain-size distribution based on changes in ore processing equipment and techniques over the period of mine operations including reported re-processing of ore in 1943 (Brooks 1971). Because the removal of such a large volume of mine waste/tailings may be cost prohibitive, it may become critical to identify "hot spots" within the waste/tailings for potential future removal actions. Further defining the nature of heterogeneity of the Waste/Tailings Pile will allow flexibility in future Removal Actions.

Roasted ore is referred to as calcine. A variety of mercury phases may be formed during roasting of mercury ores, including metacinnabar, corderoite, schuetteite ($HgSO_4$ - H_2O) and various mercury chlorides (Rytuba 2002). These minerals are soluble compared to cinnabar under typical surface oxidizing conditions, and thus are likely to be disproportionately large contributors of mercury to the environment (Rytuba 2002). During roasting of cinnabar ore, the mercury is oxidized to mercury (II), with which inorganic and organic (methyl mercury) compounds may readily form (e.g. Moore 2002).

Determining the species of mercury that may be present in the mine waste/tailings will increase our understanding of how mercury is being transported from the site. Mercury may be transported to surface water bodies by erosion of mine waste/tailings and direct transport of those materials to surface water and/or by the leaching of mercury to runoff or to groundwater. Mercury laden water could reach surface water by runoff or by groundwater through springs. Waste/tailings materials near the surface are expected to have had mobile forms of mercury leached from them already. In the subsurface leachable mercury may still be present and could serve as a source of mercury to groundwater. Determining how mercury is being transported to surface water bodies and if leachable forms of mercury are present in the subsurface will guide future Removal Actions. .

Methylmercury is the most hazardous mercury species due to its high stability, its lipid solubility, and its ionic properties that lead to a high ability to penetrate membranes in living organisms. Mercury methylation in aquatic ecosystems depends on mercury loadings, microbial activity, nutrient content, pH and redox conditions, suspended sediment load, sedimentation rates, and other variables (Eisler 1987). Determining the levels of mercury present in sediment and surface water and the species of mercury present will further define the threat of contamination from the site to human health and the environment and will further characterize the mechanism(s) for transport of mercury from the site.

Surface water and sediment from Dennis Adit may serve as a source of contaminants to the surrounding environment. A one time sampling indicated that both surface water and sediment contained significant concentrations on inorganic elements, including mercury in the sediment sample. A precipitate was observed within the adit during a site visit on June 22, 2005. Further defining the character of surface water and sediment in Dennis Creek adit will aid in determining whether the adit is a source of contaminants to the site and possibly Dennis Creek.

Decision Statement

The decisions to be made from this investigation are:

For the Main Waste/Tailings Pile to:

- Determine whether surface and subsurface mine waste in the Main Waste/Tailings Pile exceeds EPA Region 9 Preliminary Remediation Goals (PRGs) and DEQ Maximum Allowable Soil Concentrations (MASCs) for mercury and arsenic;
- Determine if the Main Waste/Tailings Pile may be a source of leachable mercury to groundwater and surface water;
- Determine if the Main Waste/Tailings Pile is a significant source of mercury contamination to Dennis Creek and creeks hydraulically downgradient of Dennis Creek;
- Determine the likely forms of mercury that migrate off site from the Main Waste/Tailings Pile;
- Refine the Main Waste/Tailings volume estimate by further delineating the pile both horizontally and vertically; and
- Assess the stability of the Main Waste/Tailings Pile with respect to erosion and slumping.

For the Old Ore Furnace to:

- Determine whether soils in the vicinity of the Old Ore Furnace exceed EPA Region 9 PRGs and DEQ MASCs for mercury and arsenic;
- Determine if the soils in the vicinity of the Old Ore Furnace are a source of leachable mercury to surface run off and to groundwater; and
- Determine the transport mechanism(s) for mercury from the Old Ore Furnace area. Currently there is evidence that suggests waste/tailings are transported from this area to Furnace Creek through erosion (DEQ 2005).

For the New Furnace Area to:

- Determine whether surface and subsurface mine waste in the new furnace area exceeds EPA Region 9 PRGs and DEQ MASCs for mercury and arsenic;
- Determine if soils in the vicinity of the New Furnace are a source of leachable mercury to surface run off and to groundwater.

For the other areas of potential contamination to:

- Determine if sediment from the "400-foot level" adit and the Dennis Creek adit exceeds EPA Region 9 PRGs for mercury and arsenic;
- Determine if water from the "400-foot level" adit and the Dennis Creek adit exceeds Federal Ambient Water Quality Criteria (AWQC) and DEQ Level II Screening Level values for mercury and arsenic; and
- Determine if these adit areas are a source of mercury to Dennis Creek and Furnace Creek.
- Determine if seeps are a source of contamination to surface water bodies.

For Sediment and Surface Water in Furnace Creek and Dennis Creek:

- Confirm that Black Butte Mine is a source of mercury to Dennis and Furnace Creeks and water bodies hydraulically downgradient of those Creeks.
- Determine the likely species of mercury present in sediment and surface water and how mercury migrates off site and downstream for BBM.

Inputs into the Decision

The following information will be provided from project activities:

- Total mercury and arsenic concentrations in surface and subsurface waste/tailings, sediment (in streams and adit), surface water (in streams and adit), and ground water (at springs) at source and target locations. This information will be gathered through the project activities described in this SSSP.
- EPA Synthetic Precipitate Leaching Procedure (SPLP) data for mercury from surface and subsurface waste/tailings.
- Selective sequential extraction of mercury data from surface and subsurface waste/tailings and from sediment and samples.

Sample Collection Information

Applicable sample collection Standard Operating Procedures (SOPs - provided at the end of the SSSP) will be followed, including Field Activity Logbooks, Sediment Sampling, Sample Packaging, Surface Water Sampling, Soil (mine waste/tailings) Sampling, Borehole Sampling, Geoprobe™ Operation, Geologic Logging, Health and Safety during Geoprobe Operations, and Sampling Equipment Decontamination.

- **Surface and Subsurface Soil (Mine Waste/Tailings):** Concentrations of total mercury in mine waste/tailings are expected to be heterogeneous both laterally and vertically over the Main Waste/Tailings Pile. Both surface and some subsurface (to a maximum depth of 26 inches) mine waste/tailings samples were collected in the SI. "Deep" continuous direct-push cores were completed to the base of the mine waste/tailings in two locations and analyzed for mercury using an XRF (DEQ 2005).

- Based on the two "deep" borings and anecdotal evidence, the Main Waste/Tailings Pile is estimated to contain approximately 300,000 cubic yards of material. The two "deep" borings cannot adequately delineate the large volume of waste/tailings. Therefore, additional "deep" borings are appropriate for surface and subsurface soil (mine waste/tailings) sample collection to refine the estimate of materials present.
- Mercury was not detected in any of the samples collected from the two "deep" borings, possibly due to the high detection limit of the XRF. The Lumex Mercury Analyzer employs differential atomic absorption spectrometry techniques to detect mercury at very low detection limits. Therefore, utilization of both an XRF Analyzer and a Lumex Mercury Analyzer for field screening surface and subsurface mine/waste tailings is appropriate for better characterization of the homogeneity of the Main Waste/Tailings Pile and to characterize and determine if hot spots are present within the Main Waste/Tailings Pile, Old Ore Furnace area, New Furnace Area, Other areas of potential contamination.
- The likely species of mercury present at the BBM site and the mechanism(s) of mercury transport from the BBM site have not been completely characterized. Characterizing the possible species of mercury present in waste rock and tailings at the BBM site as well as the leachability of the mercury that is present will further characterize the mechanism(s) and possible pathways for the transport of mercury off site. Therefore, the collection of surface and subsurface mine/waste tailings for selective sequential extraction of mercury and SPLP analysis is appropriate to characterize the possible forms of mercury present which will further characterize the mechanisms of mercury transport and potential receptors.

- **Groundwater (Seeps/Springs):** One of the identified concerns at the site is the possible leaching of mercury from mine waste/tailings which could then travel along a groundwater pathway to surface water at the site. As described above, mine waste/tailings will be analyzed for mercury species present and leachability. Although seeps/springs have been sampled previously in the SI, results are considered to be a "snap shot" in time. Therefore, further sampling of seeps/springs will further characterize groundwater as a potential pathway for mercury transport.

- **Sediment and Surface Water (Creeks and Adits):** Sediment and surface water samples have been collected from Dennis Creek and Garoutte Creek as well as locations within the Coast Fork Willamette and Cottage Grove Reservoir. Sediment samples indicate that the BBM is a source of mercury to downgradient creeks and reservoirs however, the likely species of mercury and the mechanism of mercury transport to downstream receptors have not been characterized. Mercury has not been detected in surface water samples. Therefore, the collection of sediment and surface water from Dennis Creek, Furnace Creek, and Garoutte Creek for field screening utilizing an XRF Analyzer and Lumex Mercury Analyzer is appropriate for characterizing sediment for total mercury. In addition, selective sequential extraction of mercury in sediment is appropriate to better understand potential mechanisms of mercury transport from upstream locations.

  - A one-time sampling of sediment and surface water was completed for the

Dennis Creek Adit. Concentrations of mercury in adit water are expected to fluctuate based on seasonal temperature and flow rates. Adit water could enter Dennis Creek through surface water runoff during storm events or through groundwater. Although adit water has been sampled previously, results are considered to be a "snap shot" in time, further sampling of adit sediment and adit water will further characterize the Dennis Creek adit as a possible source of mercury to Dennis Creek and Furnace Creek. The "400-foot level" adit has not been sampled previously. Therefore the sampling sediment and surface water from the Dennis Creek Adit and the "400-foot level" adit is appropriate to characterize adit discharge as a possible source area.

Decision Areas

Figure 1-2 shows the site divided into decision areas (DAs). The DAs include:

- Main Waste/Tailings Pile;
- Old Ore Furnace;
- New Furnace Area;
- Other areas of potential contamination (including adits and associated waste rock, seeps); and
- Sediment and Water in Furnace Creek and Dennis Creek (and Garoutte Creek).

Temporal Study Boundaries

The specific date that ore was last processed at the site is not known except that ore processing ended in the late 1960s.

The Decision Rule

The following statements describe the "decision rules" to apply to this investigation:

- If the concentrations of contaminants in surface or subsurface mine wastes in the Main Waste/Tailings Pile and/or in the vicinity of Old Ore Furnace and/or in the New Furnace Area exceed EPA Region 9 PRGs and DEQ MASCs, a hot spot removal and/or tailings stabilization may be necessary as part of the Removal Action.
- If a leachable form of mercury is found to be the dominant form of mercury within the mine waste materials, then one pathway for mercury migration off site may be through groundwater. If dissolved mercury is migrating off site along a groundwater pathway to surface water, then hot spot removal at the source, or some form of groundwater treatment, or capping of mine waste may be necessary as part of the Removal Action.
- If contaminants are detected in groundwater at springs, this may indicate the groundwater pathway is active, and requires further evaluation.
- If contaminants are detected in adit water, this may indicate that the groundwater pathway is active and requires further evaluation.
- If sediment is shown to have total mercury concentrations exceeding EPA Region 9 PRGs for mercury and arsenic and surface water is shown to have total mercury concentrations exceeding AWQC and DEQ Level II Screening Level values for mercury and arsenic, then a hot spot removal of creek sediment may be appropriate as part of the Removal Action. If methyl mercury and/or unstable forms of mercury are identified in sediment and surface water, then a hot spot removal of creek sediment may be appropriate as part of the Removal Action.

Limits on Decision Error

The default decision errors presented in EPA's soil screening guidance (EPA 1996) have been selected for this investigation.

Design Optimization

Sampling

All samples will be collected following applicable SOPs referenced in the 2003 E & E Generic QAPP for Sampling at Removal Program Sites.

- The objective of surface and subsurface mine waste/tailings sampling is to characterize the Main Waste/Tailings Pile, the Old Ore Furnace, and the New Furnace Area for total mercury and arsenic.
- The objective of surface and subsurface mine waste/tailings sampling for selective sequential extraction of mercury is to better understand the mechanism(s) of mercury transport from the BBM site.
- The objective of surface and subsurface mine waste/tailings sampling for SPLP analysis is to determine the potential for mine waste/tailings to serve as a source of leachable mercury, arsenic, and other metals to groundwater.
- The objective of groundwater sampling at seeps/springs for total mercury and arsenic analysis of is to determine if groundwater serves as a transport pathway for mercury contamination from the BBM site.
- The objective of sediment and surface water sampling from the Dennis Creek Adit and "400-foot level" Adit for total mercury and arsenic is to determine if the Adits serve as a source of contaminants to Dennis Creek and Furnace Creek.
- The objective of sediment and surface water sampling from Dennis Creek, Furnace Creek, and Garoutte Creek for total mercury, selective sequential extraction of mercury, and methyl mercury is to further characterize sediment and surface water and to determine the mechanism of transport to down stream receptors.

Sampling Pattern

- An average of one waste/tailings sample will be collected for every four feet of continuous core. All waste/tailings samples will be field screened using an XRF Analyzer. One of every ten waste/tailings samples will be submitted to a fixed laboratory for confirmation analysis.
- One of every ten waste/tailings samples will be submitted for selective sequential extraction of mercury and SPLP analysis.
- One groundwater sample will be collected from each seep/spring identified on site and field screened using an XRF Analyzer and a Lumex Analyzer. Two seeps/springs are expected to be identified.
- One set of sediment and surface water samples from the Dennis Creek Adit and one set from the "400-foot level" Adit will be field screened using an XRF Analyzer and a Lumex Analyzer.
- One set of co-located sediment and surface water samples will be collected from the following locations on Dennis Creek: background, downslope of Dennis Creek adit (where adit flow might be expected to enter Dennis Creek during high flows), below tailings, below mine road, at the confluence with Garoutte Creek. One set of co-located sediment and surface water samples will be collected from the following locations on Furnace Creek: background, below tailings, between tailings and confluence with Garoutte Creek, and at the confluence with Garoutte Creek. One set of co-located sediment and surface water samples will be collected from the following locations on

Garoutte Creek: background, below Furnace Creek, below Dennis Creek. All sediment and surface water samples will be field screened using an XRF Analyzer and a Lumex Analyzer. One of every ten sediment and surface water samples will be submitted to a fixed laboratory for confirmation analysis.

- Three sediment samples will be submitted for selective sequential extraction of mercury and methyl mercury analysis. If total mercury is identified in surface water, then ~~three~~ TWO surface water samples will be submitted for methyl mercury analysis.

Numbers of Samples

- Sixty-four to 80 waste/tailings samples will be collected for field-screening. Ten percent of the samples, or 8 samples, representing a range of concentrations will be sent to a fixed laboratory for confirmation of field-screening results.
- Eight waste/tailings samples will be collected for selective sequential extraction of mercury and SPLP analysis.
- Up to two groundwater samples are expected to be collected from springs for field screening.
- Two sets of sediment and surface water samples are expected to be collected from Dennis Creek Adit and the "400-foot level" Adit for field screening.
- Twelve to fifteen co-located sediment and surface water samples will be collected for field screening. Ten percent of the samples, or 2 samples, will be sent to a fixed laboratory for confirmation of field-screening results.
- Three co-located surface water and sediment samples will be collected for mercury speciation analysis. The surface water samples will be analyzed for methyl mercury and the sediment samples will be submitted for selective sequential extraction of mercury.

Types and Locations of Samples

Samples will be collected from the DAs.

- Continuous cores of mine waste/tailings from 16 to 20 borings in the Main Waste/Tailings pile, the Old Ore Furnace, and the New Furnace Area will be field screened using X-ray fluorescence (XRF) techniques for total metals using a portable NITON 700 series XRF analyzer. XRF techniques will facilitate more focused collection of samples for fixed laboratory analysis. The use of XRF techniques reduces laboratory analytical costs. Ten percent of samples field screened with an XRF will be sent to a fixed laboratory for confirmation analysis. The XRF provides screening levels on other metals that may be present and of concern at the site.
- Waste/tailings samples for selective sequential extraction of mercury will be selected at the discretion of the field team based on the results of samples field screened using the XRF and submitted to a fixed laboratory for analysis.
- Groundwater samples will be collected from two springs identified on site. Groundwater will be field tested for pH, temperature, dissolved oxygen, reduction potential and conductivity. Groundwater samples will be field screened for total mercury and arsenic utilizing a Lumex RA-915+ Mercury Analyzer.
- Sediment and surface water samples from Dennis Creek Adit and the "400-foot level" Adit will be field screened for total mercury and arsenic utilizing a portable NITON 700 series XRF analyzer and a Lumex RA-915+ Mercury Analyzer.
- Co-located sediment and surface water samples will be collected at background locations, Dennis Creek, Furnace Creek, and Garoutte Creek and field screened for total mercury and arsenic utilizing a portable NITON 700 series XRF analyzer and a Lumex RA-915+ Mercury Analyzer. Ten percent of samples will be sent to a fixed laboratory for confirmation analysis.

- Sediment samples for mercury speciation analysis and methyl mercury analysis will be selected at the discretion of the field team based on the results of samples field screened using the XRF and/or Lumex analyzer(s) and submitted to a fixed laboratory for analysis. Co-located surface water samples will be submitted to a fixed laboratory for methyl mercury analysis.

Sample Matrix and Target Analytes

- Waste/tailings samples will be field screened for total mercury and arsenic. A minimum of 10% of the field samples will also be analyzed at a fixed laboratory for confirmation purposes for TAL Metals by EPA Method 6000/7000 series.
- Ten percent of waste/tailings samples will be analyzed using selective sequential extraction of mercury.
- Ten percent of waste/tailings samples analyzed for SPLP Metals by EPA Method 1312/EPA 6000/7000 series.
- Sediment and surface water samples will be field screened for total mercury and arsenic. A minimum of 10% of the field samples will also be analyzed at a fixed laboratory for confirmation purposes for TAL Metals by EPA Method 6000/7000 series.
- Three sediment samples will be analyzed using selective extraction for mercury speciation. In addition, the samples will be analyzed for methyl mercury.
- ~~Three~~ two surface water samples will be analyzed for methyl mercury.

Methods will be those referenced in the 2003 E & E Generic QAPP for Sampling at Removal Program Sites and listed below. See Tables 2-1, 2-2, 2-3 and 2-4 for sample collection and analysis information. The Sample Plan Alteration Form (a blank form is included at the end of this document) will list project discrepancies (if any) that occurred between planned project activities listed in the final SSSP and actual project work.

Table 2-1

SAMPLE INFORMATION SUMMARY
BLACK BUTTE MINE
LANE COUNTY, OREGON

Project Sampling Schedule[a]	Parameter/ Limits[b]	Design Rationale	Sampling Design Assumptions	Sample Selection Procedures	Measurement Classification (Critical/Non Critical)	Nonstandard Method Validation
Soil (mine waste/ tailings)	Total Hg, As/MDL Hg Speciation/MDL SPLP Hg/MDL	To determine the distribution of contaminants within mine waste/tailings pile and their mobility.	Contaminants are present in mine waste/tailings piles. Mine waste/tailings pile is heterogeneous.	Samples will be collected based on XRF field screening.	Critical	Per method
Groundwater (springs and adit water)	Total Hg, As/MDL Hg Speciation/MDL	To determine if Hg and As are entering surface water in the dissolved phase.	Contaminants were released to the water.	Samples will be collected from springs identified on or near BBM.	Critical	Per method
Surface Water	Total Hg, As (filtered and unfiltered)/MDL Hg Speciation/MDL	To determine if Hg is present in surface water in the dissolved phase or as suspended solids.	Contaminants were released to surface water as dissolved Hg or as Hg attached to suspended solids.	Samples will be collected from potentially contaminated areas and background locations.	Critical	Per method
Sediment	Total Hg, As/MDL Hg Speciation/MDL	To determine if contaminants are present in on- and off-site sediment.	Contaminants were released to the sediment.	Samples will be collected from potentially contaminated area and background locations.	Critical	Per method

[a] All samples will be collected during the field event. The listed items are the media to be sampled in the decision areas.
[b] Detection limits will be CRQL for Contract Laboratory Program methods and MDL for field and commercial laboratory methods.
[c] As indicated from previous investigations at the site and from on-site observations. All locations will be determined by the OSC and START-2 Field Team.

Key:

As	= Arsenic.
BBM	= Black Butte Mine.
CRQL	= Contract required detection limit.
Critical	= Required to achieve project objectives or limits on decision errors.
Hg	= Mercury.
MDL	= Method detection limits.
NA	= Not applicable.
Noncritical	= For informational purposes only or needed to provide background information.
SPLP	= Synthetic Precipitate Leaching Procedure.

Table 2-2
SAMPLE ANALYSES SUMMARY
BLACK BUTTE MINE
LANE COUNTY, OREGON

Matrix	Location [a]	Analytical Parameters/Method[b]	Sample Preservation	Technical Holding Time[c]	Sample Container(s)
Soil (mine waste/ tailings)	TBD	As and Hg/EPA SW-846 Method 6200 As and Hg/EPA SW-846 7000 Series Methods Hg Speciation/Lab Proprietary Method SPLP Hg/EPA SW-846 Methods 1312 and 7471	Cool to 4 °C ± 2 °C	180 days from collection (28 days for mercury)	One 8-oz wide-mouth glass jar with Teflon-lined lid
Groundwater (springs and adit water)	TBD	As and Hg (Filtered and Unfiltered)/ EPA SW-846 7000 Series Methods Methyl mercury/Lab Proprietary Method	Cool to 4 °C ± 2 °C HNO_3 to pH ≤ 2	180 days from collection (28 days for mercury)	One 1-Liter Polyethylene bottle with Teflon-lined lid
Surface Water	TBD	As and Hg (Filtered and Unfiltered)/ EPA SW-846 7000 Series Methods Methyl mercury/Lab Proprietary Method	Cool to 4 °C ± 2 °C HNO_3 to pH ≤ 2	180 days from collection (28 days for mercury)	One 1-Liter Polyethylene bottle with Teflon-lined lid
Sediment	TBD	As and Hg/EPA SW-846 Method 6200 As and Hg/EPA SW-846 7000 Series Methods Hg Speciation/Lab Proprietary Method	Cool to 4 °C ± 2 °C	180 days from collection (28 days for mercury)	One 8-oz wide-mouth glass jar with Teflon-lined lid

[a] The number of samples presented is an estimate; the actual number of samples to be collected will be determined in the field.
[b] In general, preservation, holding times, and containers for soil and water TAL metals and VOCs are those listed under the associated analytical laboratory method.
[c] Technical holding times have been established only for water matrices. Water and/or recommended holding times were applied to air, sediment, soil, and product samples where applicable.

Key:

°C	= Degrees celsius.	oz	= Ounce.
EPA	= United States Environmental Protection Agency.	SPLP	= Synthetic Precipitate Leaching
HNO_3	= Nitric acid.	TBD	= To be determined.

The laboratories' DQOs for completeness and the field team's ability to meet the DQO for representativeness are set at 90%. Precision and accuracy requirements are outlined in Table 2-3.

Table 2-3

QA/QC ANALYTICAL SUMMARY and FIXED LABORATORY ANALYTICAL METHODS
BLACK BUTTE MINE
LANE COUNTY, OREGON

Laboratory	Matrix	Parameters/Method	Method Description /Detection Limits	Total Field Samples[a]/ Containers	QA/QC Sample Summary Analyses / Containers: Organic MS/MSD[b]	Inorganic MS/Dup[b]	Rinsate Blanks[c]	Trip Blanks[d]	Total Field and QA/QC Analyses/ Containers[e]	Precision and Accuracy
Field Analysis	Soil/ Sediment	Hg & As / EPA SW-846 Method 6200	XRF/MDL	80 / NA	NA	NA	NA	NA	80 / NA	NA
EPA Region 10 or Commercial Laboratory	Soil/ Sediment	TAL metals/EPA SW-846 6000 and 7000 Series Methods	AA/MDL	8 / 8	NA	1 / 0	NA	NA	9 / 8	75% - 125% ± 35%
		Hg Speciation/Lab Proprietary Method	AA/MDL	8 / 8	NA	1 / 0	NA	NA	9 / 8	Per Method
		SPLP Hg/EPA SW-846 Methods 1312 and 7471	AA/MDL	8 / 8	NA	1 / 0	NA	NA	9 / 8	75% - 125% ± 35%
	Water	As and Hg (Filtered and Unfiltered)/ EPA SW-846 7000 Series Methods	AA/MDL	2 / 2	NA	1 / 1	NA	NA	3 / 3	75% - 125% ± 35%
		Methyl mercury/Lab Proprietary Method	AA/MDL	2 / 2	NA	1 / 1	NA	NA	3 / 3	Per Method

a Total number of field samples is estimated.

b No extra volume is required for soil/sediment or product samples; for water samples, triple volume is required for organic analyses, and double volume is required for inorganic analyses. Sample numbers are based on 1 matrix spike/matrix spike duplicate (MS/MSD) per 20 samples per matrix.

c The total number of rinsate samples could vary depending on the total number of samples collected. The sample numbers are based on one rinsate per 20 samples per nondedicated sampling device. Note that rinsate blanks consist of water aliquots for both soil and water field samples.

d The total number of trip blanks could vary depending on the total number of sample shipments. This number is based on the estimated number of shipping containers. Note that trip blanks consist of water aliquots for both soil and water field samples.

e Total analyses and containers includes both field and QA/QC aliquots to be submitted for fixed laboratory analysis. Note that trip blanks and rinsate blanks consist of water aliquots for both soil and water field samples.

Key:

AA	= Atomic absorption furnace technique	MS/MSD	= Matrix spike/matrix spike duplicate.	QC	= Quality control.
EPA	= Environmental Protection Agency.	NA	= Not applicable.	XRF	= X-ray fluorescence.
MDL	= Method detection limit	QA	= Quality assurance		

Table 2-4

SAMPLE CODING
BLACK BUTTE MINE
LANE COUNTY, OREGON

Digits	**Descriptions**	**Code Example**
1,2	~~Decision Area~~	MP (Main Waste/Tailings Pile) OF (Old Ore Furnace) NF (New Furnace Area) OA (Other Areas of Potential Contamination) CK (Sediment and Water in Furnace & Dennis Creeks)
3,4	Consecutive Sample Number	01 (First Sample of Decision Area)
5,6	Matrix Code	SS (Soil) SM (Source Material) GW (Groundwater) SW (Surface Water) SD (Sediment) QC (Quality Control) WT (Water)
7,8	Consecutive Sample Number	01 (~~First sample of Matrix Code~~)

Depth of Sample @ Bottom of Interval

REFERENCES

Brooks, H.C., 1971,*Quicksilver Deposits in Oregon*, Oregon Department of Geology and Mineral Industries, Miscellaneous Paper No. 15.

Ecology & Environment (E & E), 1999, *Black Butte Mine Site Inspection*, prepared for the United States Environmental Protection Agency, Seattle, Washington.

Moore, R.L., 2002, *Mercury Contamination Associated with Abandoned Mines*, Oregon Geology, Volume 64, Number 1, Spring 2002.

Oregon Department of Environmental Quality (DEQ), 2005, *Removal Assessment Conceptual Scope of Work*, April 14, 2005.

______, 1996, *Preliminary Assessment, Black Butte Mine*, prepared for the United States Environmental Protection Agency, Region 10, by Keith Anderson, Site Assessment Section, Eugene, Oregon.

Oregon State University (OSU), 2004, *Reconnaissance Soil Sampling at the Black Butte Mine,* prepared for the Oregon Department of Environmental Quality, Larry R. Curtis, Department of Environmental & Molecular Toxicology, August 9, 2004.

______, 2003, *Sources and Chronology of Mercury Contamination in Cottage Grove Reservoir,* prepared for the U.S. Army Corps of Engineers, Portland, Oregon, Larry R. Curtis, Department of Environmental & Molecular Toxicology, May 20, 2003.

______, 1994, Unpublished data collected by the OSU Department of Fisheries and Wildlife, Jeong-Gue Park.

______, 1992, Unpublished data collected by the OSU Department of Fisheries and Wildlife, Jeong-Gue Park.

______, 1990, *An Ecoregion Approach to Mercury Dynamics in Three Oregon Reservoirs*, Susan M. Allen and Larry R. Curtis, Oak Creek Laboratory of Biology, Department of Fisheries and Wildlife, June 10, 1991.

Rytuba, J.J., 2002, *Mercury Geoenvironmental Models for Selected Mineral Deposit Types*, Robert R. Seal II and Nora K. Foley, Editors, U.S. Geological Survey Open-File Report 02-195 Online Version 1.0.

United States Environmental Protection Agency (EPA), 1996, *Soil Screening Guidance: User's Guide (Second Edition)*, Publication 9355.4-23, July 1996.

United States Fish and Wildlife Service (USFWS), 1992, *Results of Cottage Grove Bald Eagle Egg Analysis*, Fact Sheet.

United States Geological Survey (USGS), 1993, Sediment Mercury Data, Multiple Station Analysis, 1992 and 1993, unpublished.

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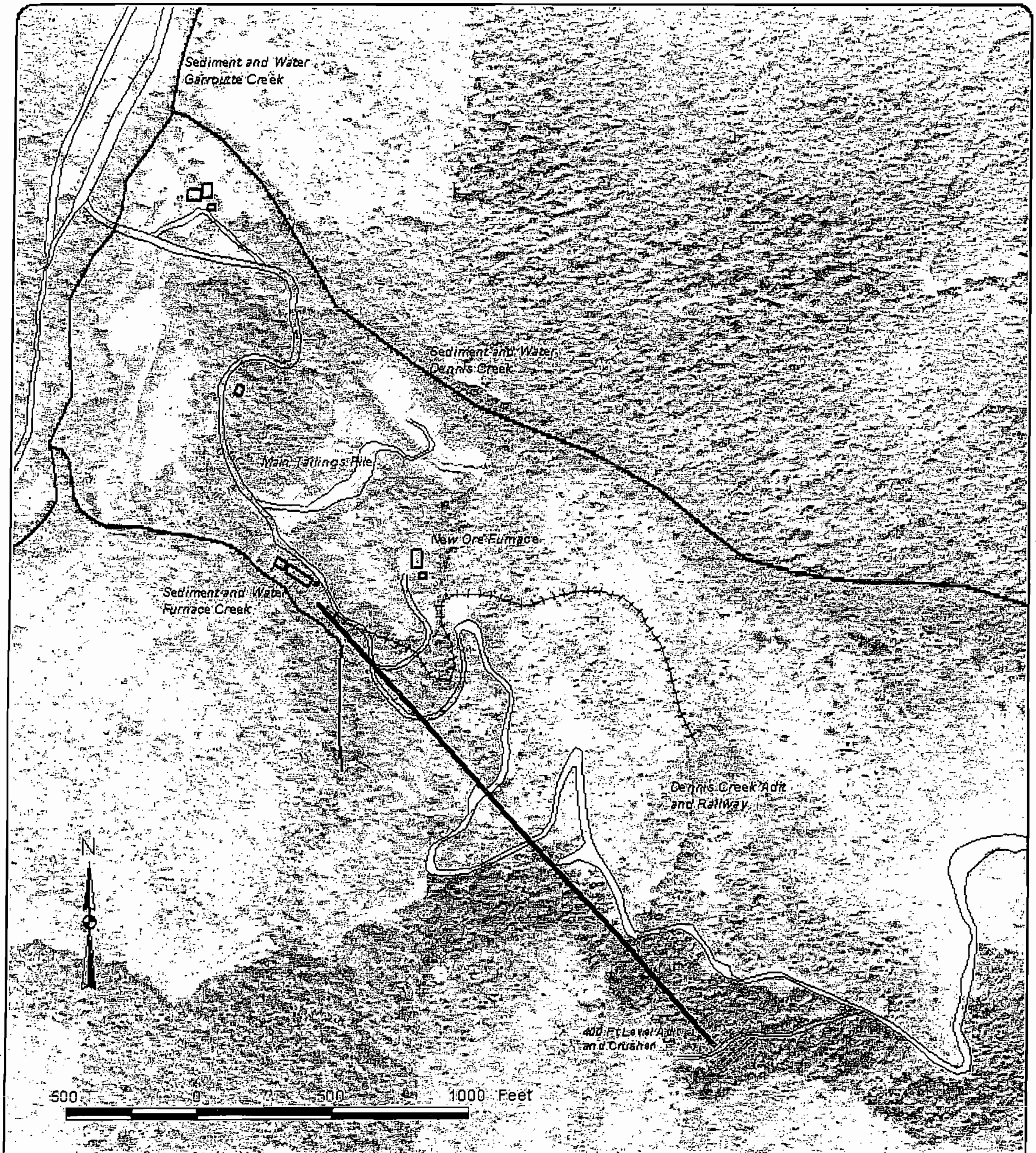
Sample Plan Alteration Form

Project: Black Butte Mine

TDD Number: 05-04-0005

Changes from Final SSSP (include rationale, decision area, matrices, parameters, equipment, personnel, etc.):

APPROVALS			
Name	**Title**	**Signature**	**Date**
Marc Callaghan	On Scene Coordinator	MCallaghan	Sept 6, 2005
Erin Lynch	START-2 Project Manager		
Mark Woodke	START-2 Quality Assurance Officer		



Site Structures
Creeks and Streams
Roads
Former Tramway
Former Railway
Areas of Contamination

Figure 3
Areas of Contamination
Black Butte Mine
Removal Assessment Scope

DEQ

Google Maps

Start **4545 SW Dogwood Dr**
Lake Oswego, OR 97035
End **Cottage Grove, OR**
Travel **120 mi (about 2 hours 0 mins)**

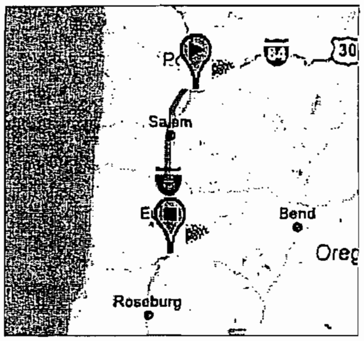
4545 SW Dogwood Dr
Lake Oswego, OR 97035
Drive: 120 mi (about 2 hours 0 mins)

1. Head **west** on **SW Dogwood Dr** toward **SW Sycamore Ave**	**0.2 mi**
2. Turn **right** at **SW Sycamore Ave**	**0.2 mi**
3. Turn **left** at **SW Childs Rd**	**0.3 mi** 1 min
4. Turn **right** at **Pilkington Rd**	**1.1 mi** 2 mins
5. Turn **left** at **Lower Boones Ferry Rd**	**0.8 mi** 2 mins
6. Turn **left** to merge onto **I-5 S** toward **Salem**	**115 mi** 1 hour 50 mins
...	
7. Take the **E Cottage Grove Conn** exit **174** to **Cottage Grove**, keep following signs	**0.4 mi** 1 min
8. Merge onto **E Cottage Grove Conn**	**0.4 mi**
9. Slight **left** at **N Goshen-Divide Hwy**	**0.2 mi**
10. Continue on **N 9th St**	**0.3 mi**
11. Turn **left** at **E Gibbs Ave**	**253 ft**
12. Turn **right** at **N 10th St**	**289 ft**
13. Slight **right** at **N Lane St**	**95 ft**

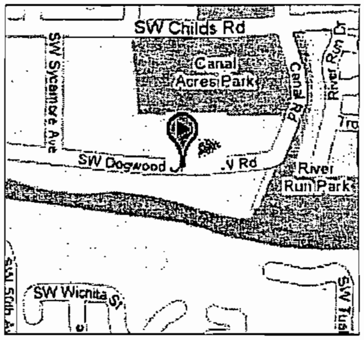
Cottage Grove, OR

These directions are for planning purposes only. You may find that construction projects, traffic, or other events may cause road conditions to differ from the map results.

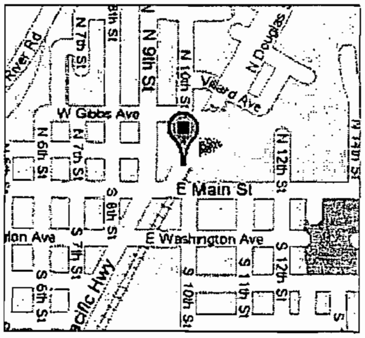
Overview



Start



End



Title:	FIELD ACTIVITY LOGBOOKS
Category:	DOC 2.1
Revised:	April 1998

STANDARD OPERATING PROCEDURE

FIELD ACTIVITY LOGBOOKS

ecology and environment, inc.
368 Pleasant View Drive / Lancaster, New York 14086 / (716) 684-8060

TITLE:	FIELD ACTIVITY LOGBOOKS		
CATEGORY:	DOC 2.1	REVISED:	April 1998

TABLE OF CONTENTS

1. Summary

This Standard Operating Procedure (SOP) establishes requirements for the entry of information into logbooks to ensure that E & E field activities are properly documented. The project manager (PM) and the field team leader (FTL) are responsible for ensuring that logbook entries provide sufficient information for the completion of an accurate and detailed description of field operations and meets the requirements of the contract or technical direction document (TDD).

This SOP describes logbook entry requirements for all types of projects, specifies the format that should be used, and provides examples. Some flexibility exists when implementing the SOP because different types of projects require different data collection efforts. This SOP does not address site safety logbook requirements or geotechnical logbook entries.

2. Purpose

Complete and accurate logbook entries are important for several reasons: to ensure that data collection associated with field activities is sufficient to support the successful completion of the project; to provide sufficient information so that someone not associated with the project can independently reconstruct the field activities at a later date; to maintain quality control (QC) throughout the project; to document changes to or deviations from the work plan; to fulfill administrative needs of the project; and to support potential legal proceedings associated with a specific project.

2.1 Adequate Field Information/Quality Control

QC procedures for data collection begin with the complete and systematic documentation of all persons, duties, observations, activities, and decisions that take place during field activities. It is especially important to fully document any deviations from the contract, project scope, work plans, sampling plans, site safety plans, quality assurance (QA) procedures, personnel, and responsibilities, as well as the reasons for the deviations.

Prior to entering the field, the project manager must indicate to the field team what pertinent information must be collected during field activity in order to meet the desired objectives of the data collection effort. The PM is responsible for reviewing the adequacy of the project logbooks both during and following completion of field activities, and is also responsible for meeting with the field team members to discuss any findings and to direct activities to correct any deficiencies, as appropriate. The PM also has the responsibility of ensuring that the logbooks become part of the project or TDD file.

2.2 Work Plan Changes/Deviation

The logbook is the document that describes implementation of the work plan and other appropriate contract documents and provides the basis for the project reports. It must include detailed descriptions of any and all deviation from the work plan and the circumstances that necessitate such changes. These changes will be reviewed for compliance with data quality objectives and include:

- Changes in procedures agreed to in the project planning stages;
- Any conditions that prevent the completion of the field effort, or that result in additional fieldwork must be noted (i.e., weather delays, government actions, physical obstructions, personnel/ equipment problems, etc.). Persons from whom permission was obtained to make such changes must be clearly documented.
- Any modifications requested by the client or client's representative that are contradictory to the contract or outside of the existing scope of work must be documented in detail because the cost of the project could be affected by such modifications.

2.3 Evidentiary Documentation

Field activity documentation can become evidence in civil and/or criminal judicial proceedings, as well as in administrative hearings. Field logbooks serve this purpose. Accordingly, such documentation is subject to judicial or administrative review. More importantly, it is subject to the review of an opposing counsel who will attempt to discredit its evidentiary value.

The National Enforcement Investigation Center (NEIC) and the United States Environmental Protection Agency (EPA) have prepared documents outlining their documentation needs for legal proceedings. These guidelines indicate the importance of accurate and clear documentation of information obtained during the inspections, investigations, and evaluations of uncontrolled hazardous waste sites. Consequently, attention to detail must be applied by E & E personnel to all field documentation efforts for all E & E projects. Project personnel must document where, when, how, and from whom any vital project information was obtained. This information is necessary to establish a proper foundation for admissible evidence.

3. Guidelines

Logbooks should contain a summary of any meeting or discussion held with a client or with any federal, state, or other regulatory agency that was on site during the field activities. The logbook should also describe any other personnel that appear on site, such as representatives of a potential responsible party (PRP).

The logbook can be used to support cost recovery activities. Data concerning site conditions must be recorded before the response activity or the passage of time eliminates or alters those conditions. Logbooks are also used to identify, locate, label, and track samples and their final disposition. In addition, data recorded in the logbook will assist in the interpretation of the analytical results.

Logbooks are subject to internal and external audits. Therefore, the recorded information should be consistent with and capable of substantiating other site documentation such as time cards, expense reports, chain-of-custody forms, shipping papers, and invoices from suppliers and subcontractors, etc. Logbooks also act as an important means of reconstructing events should other field documents such as data collection forms become lost or destroyed. Therefore, all mission-essential information should be duplicated in the logbook.

3.1 General Instructions

The following general guidelines must be used for all logbooks:

- At a minimum, one separate field activity logbook must be maintained for each project or TDD.
- All logbooks must be bound and contain consecutively numbered pages.
- No pages may be removed for any reason, even if they are partially mutilated or illegible.
- All field activities must be recorded in the site logbook (e.g., meetings, sampling, surveys, etc.).
- All information must be **printed legibly** in the logbook using water-proof ink, preferably black. If weather conditions do not permit this (i.e., if it is too cold or too wet to write with ink), another medium, such as pencil, may be used. The reason that waterproof ink was not used should be specifically noted in the logbook.
- The language used in the logbook should be objective, factual, and free of personal feelings or terminology that might prove inappropriate.
- Entries should be made in chronological order. Contemporaneous entries are always preferred because recollections fade or change over time. Observations that cannot be recorded during field activities should be recorded as soon after as possible. If logbook entries are not made during field activities, the time of the activity/ observation and the time that it is recorded should be noted.
- The first entry for each day will be made on a new, previously blank page.
- Each page should be dated and each entry should include the time that the activity occurred based on the 24-hour clock (e.g., 0900 for 9 a.m., 2100 for 9 p.m.).
- At the completion of the field activity, the logbook must be returned to the permanent project or TDD file.

3.2 Format

The information presented below is not meant to be all-inclusive. Each project manager is responsible for determining the specific information requirements associated with a field activity logbook. If someone other than the Project Manager is keeping the logbook, the Project Manager is responsible to convey to that individual, prior to the start of fieldwork, specific instructions on what type of information is required to be entered into the logbook. Information requirements will vary according to the nature and scope of the project. (Refer to Appendix A for an example of a completed logbook.)

Title Page

The logbook title page should contain the following items:

- Site name,
- Location,
- TDD No. or Job No.,
- PAN (an EPA site/task identification number), if applicable,
- SSID No. (Site ID number-assigned under CERCLA), if applicable,
- Start/Finish date, and
- Book ___ of ___.

First Page

The following items should appear on the first page of the logbook prior to daily field activity entries:

- TDD No. or Job No.,
- Date,
- Summary of proposed work (Reference work plan and contract documents, as appropriate),
- Weather conditions,
- Team members and duties, and
- Time work began and time of arrival (24-hour clock).

Successive Pages

In addition to specific activity entries and observations, the following items should appear on every logbook page:

- Date,
- TDD or Job No., and
- Signature (bottom of each page). If more than one person makes entries into the logbook, each person should sign next to his or her entry.

Last Page

In addition to specific activity entries and observations and the items that should appear on each successive page, the last page of the logbook should contain a brief paragraph that summarizes the work that was completed in the field. This summary can become especially important later on if more or less work was accomplished during the duration of the field activity.

3.3 Corrections

If corrections are necessary, they must be made by drawing a single line through the original entry in such a manner that it can still be read. *Do not erase or render an incorrect notation illegible.* The corrected entry should be written beside the incorrect entry, and the correction must be initialed and dated. Most corrected errors will require a footnote explaining the correction.

4. Documentation

Although the requirements and content of the field logbook will vary according to the site and the tasks to be performed, the following information should be included in every logbook:

4.1 Prior to Fieldwork

Summary of Proposed Work

The first paragraph of **each** daily entry should summarize the work to be performed on that day. For example:

> "Collect soil and groundwater samples from previously installed wells and ship samples to Analytical Services Center (ASC). Discuss removal with site owner."

The first paragraph becomes especially important later when discussing work plan deviations or explaining why more or less work was accomplished for that day.

Personnel

Each person to be involved in activities for the day, his/her respective role (sampler, health and safety, etc.), and the agency he/she represents should be noted in the logbook.

On-Site Weather Conditions

Weather conditions may have an impact on the work to be performed or the amount of time required to perform the proposed work; therefore, all weather on-site weather conditions should be noted, including temperatures, wind speed and direction, precipitation, etc., and up-dated as necessary. Similarly, any events that are impacted by weather conditions should be noted in the logbook.

Site Safety Meeting

Although minutes should be recorded for all site safety meetings under separate cover, the logbook should briefly summarize the site safety meeting and any specific site conditions and resultant site safety concerns.

4.2 Site Sketch

A site sketch should be prepared on the first day of field activities to indicate prominent site and environmental features. The sketch should be made either to scale or by noting the ap-proximate distances between site feature. Area-specific sketches should be prepared as work is undertaken in such areas, and updated sketches should be drawn as work progresses.

Site Features

Examples of features to be noted on the site sketch include the following:

- Structures such as buildings or building debris;
- Drainage ditches or pathways, swales, and intermittent streams (include direction of overland runoff flow and direction of stream flow);
- Access roads, site boundaries, and utility locations;
- Decontamination and staging areas;
- Adjacent property data: the type of property that borders the site, in-formation pertaining to ownership, and available addressees; and
- North arrow.

Changes in Site Conditions

Any deviation from previous site sketches or drawings presented in the work plan, and any changes that have occurred since the last site visit must be noted. Differences to be noted include the following:

- Demolished buildings;
- Changes to access routes;
- Damage to wells or equipment, or changes to the amount of such equipment believed to be on site,
- Changes resulting from vandalism;
- Destruction of reference points;
- Changes resulting from environmental events or natural disasters; and
- Locations of excavations, waste piles, investigation-derived waste (IDW), drum staging areas, etc.

In short, *any* site condition that varies from the conditions described in the work plan should be noted.

4.3 Monitoring Equipment and Activities

Any monitoring equipment used during field activities should be documented in the log-book. Information to be noted includes:

- The type of equipment with model and serial numbers. (HNu, OVA, etc.);
- The frequency at which monitoring is performed;
- Calibration results and the frequency at which the equipment is cali-brated or tested;
- Background readings;
- Any elevated or unusual readings; and
- Any equipment malfunctions.

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It is particularly important to note elevated or unusual equipment readings because they could have an impact on personal protection levels or the activities to be performed on site. If a change in the proposed work or protection levels occurs, it should be clearly noted in the logbook.

4.4 Sample Collection Activities

Because it represents the first step in an accurate chain-of-custody procedure, field sampling documentation must be complete. The following items should be documented in the logbook:

Sample Collection Procedures

The following items pertaining to sample collection procedures should be included in the logbook:

- Any pre-sampling activities (i.e., well purging and the number of volumes purged before sample collection);
- Results of the pre-sampling activities (i.e., pH/conductivity/ temperature readings for well water, results of hazard categorization testing, etc.);
- Any environmental conditions that make sample collection difficult or impossible (i.e., dry or flooded drainage paths, inclement weather conditions, etc.); and
- Any deviation from the work plan (i.e., additional samples and the reason for their collection, alternate sample locations, etc.).

Sample Information

The following information regarding sample data should be recorded in the logbook:

- Sample number and station location including relationship to permanent reference point(s);
- Name(s) of sampler(s);
- Sample description and any field screening results;
- Sample matrix and number of aliquots if a composite sample;
- Preservatives used, recipient laboratory, and requested analyses;
- QA/QC samples; and
- Shipping paper (airbill) numbers, chain-of-custody form numbers, and jar lot numbers.

Investigation-Derived Waste/Sample Shipment

Details pertaining to sampling equipment, decontamination, and IDW should be clearly delineated in the work plan. However, the following information should be included in the log-book:

- The type of IDW generated an the number of containers generated (each drum should be numbered and its contents noted);
- All information relevant to the characterization of the IDW;
- Any directions received from the client/workplan/contract relative to the management of the IDW;
- The disposition of IDW (left on site or removed from site);
- The number of sample containers shipped to the ASC or laboratory and the courier used (i.e., Federal Express, Airborne Express, etc.);
- Airbill or shipment tracking numbers; and
- The type of paperwork that accompanied the waste/sample shipment (e.g., manifests, etc.).

4.5 Photodocumentation

Photographs should be taken during all relevant field activities to confirm the presence or absence of contaminants encountered during fieldwork. Specific items to be documented include:

- Sample locations and collection activities;
- Site areas that have been disturbed or impacted, and any evidence of such impacts (i.e., stressed vegetation, seepage, discolored water, or debris);
- Hazardous materials requiring disposal, including materials that may not appear in the work plan;
- Any evidence that attests to the presence or absence of contamination; and
- Any features that do not appear in the work plan or differ from those described in the work plan.

Documentation of any photographs taken during the course of the project must be provided in the logbook with a detailed description of what is shown in the photograph and the reason for taking it. This documentation should include:

- Make, model, and serial numbers of the camera and lens,
- Film type and number of exposures,
- Roll and frame number of the photograph;
- Direction or view angle of the photograph, and
- Name of the photographer.

4.6 Data Collection Forms

Certain phases of fieldwork may require the use of project-specific data collection forms, such as task data sheets or hazard categorization data sheets. Due to the specific nature of these forms, the information that should be included in the logbook cannot be fully discussed in this SOP. However, the following data should be included in the logbook:

- Results of any field tests or hazard categorization tests (i.e., ignitability, corrosivity, reactivity, etc.);
- The source from which any field sample was collected and its condition (i.e., drum, tank, lagoon, etc.).
- Other conclusions as a result of the data collected on data collection forms.

In many cases, rubber stamps that contain routine data collection forms can be manufactured ahead of time. These forms can be stamped into the logbook on an as-needed basis.

Appendix A

Sample Logbook

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WEDNESDAY JANUARY 26, 1994

PROPOSED WORK FOR DAY: COLLECT GROUNDWATER SAMPLES FROM WELLS AND PIEZOMETERS AT SITE 1 AND SITE 3. SHIP SAMPLES TO THE ASC. CONTAINERIZE PURGE WATER. MEET WITH FRED CANSLER AND DISCUSS REMOVAL OF CANOPIES AT SITES 1 AND 3 AND FILLING OF EXCAVATIONS.

WEATHER ON SITE: CLOUDY AND WARM WITH A HIGH TEMPERATURE OF 50° F. RAIN SHOWERS WITH WINDS FROM THE SW AT 5-15 MPH.

E+E PERSONNEL ON SITE: G. JONES, J. MAYS, S. MC COIS

LOG

1330 ARRIVED ON SITE. THE GROUNDWATER SAMPLING CREW WAS PREPARING TO PURGE THE WELLS AND PIEZOMETERS IN THE FIELD ACROSS THE ROAD FROM SITE 1. PURGING OF WELLS BEING COMPLETED WITH HAND BAILERS SINCE PUMP IS INOPERATIVE.

1340 ARRIVED AT SITE 3. MW3-1 AND MW3-8 UNLOCKED AND OPEN; SECURED BOTH WELLS.

 [signature] 1/26/94

1350 FRED CANSLER ARRIVED ON SITE. DISCUSSED REMOVAL OF CANOPIES AND CLOSURE OF EXCAVATIONS AT SITES 1 AND 3. FRED CANSLER STATED THAT HE HAS A SOURCE FOR THE FILL AND FOR THE TOP SOIL FOR THE EXCAVATIONS.

1405 ARRIVED AT THE SITE WHERE FRED CANSLER PROPOSES TO REMOVE THE FILL FOR THE EXCAVATIONS. A HILL ON THE WEST SIDE ~~OF~~ OF THE WOODEN NICKLE IS IN THE PROCESS OF BEING REMOVED. THE ROCK CONSISTS OF WEATHERED SHALE SIMILAR TO THE ROCK REMOVED FROM THE EXCAVATIONS. FRED CANSLER PROPOSES TO USE THE ROCK TO FILL THE EXCAVATIONS TO WITHIN ONE FOOT OF GRADE.

1415 ARRIVED AT THE SITE WHERE FRED CANSLER PROPOSES TO REMOVE TOP SOIL FOR THE EXCAVATIONS. TOP SOIL REMOVED FROM THE YELLOW FREIGHT LOT IS IN PILES ON THE NORTH SIDE OF THE LOT.

1430 RETURNED TO SITE 3. FRED CANSLER WILL ARRANGE TO REMOVE THE CANOPY OVER THE EXCAVATION AT SITE 3 ON THURSDAY MORNING AND WILL ARRANGE TO BRING THE ROCK IN ON THURSDAY AFTERNOON. TWO TRUCKS WILL BE USED TO HAUL THE FILL. THE SUPPORTS HOLDING THE CANOPY

 [signature] 1/26/94

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1430 (CONT) WILL BE CUT AND THE CANOPY DRAGGED AWAY FROM THE EXCAVATION.

1445 CONTACTED JOY WHAN FROM ENVIROCHEM. TANKERS WILL BE ON SITE ON THURSDAY TO PUMP OUT THE EXCAVATION AT SITE 3 AND ON FRIDAY TO REMOVE WATER AT SITE 1. A FRAC TANK WILL BE DELIVERED TO SITE 1 ON THURSDAY.

1515 SAMPLING CREW COMPLETED: PIEZOMETER SAMPLES COLLECTED AT SITE 1. ALL WELLS AND PIEZOMETERS AT SITE 1 HAVE BEEN SAMPLED.

1530 SAMPLING CREW COMPLETED PACKING SAMPLES AND SECURING DRUMS OF PURGE WATER.

1535 SAMPLING CREW DEPARTED SITE TO DELIVER SAMPLES TO FEDERAL EXPRESS.

1600 CONTACTED TIM GRADY FROM E+E. DISCUSSED CONVERSATION WITH FRED CANSLER AND STATUS OF WELL/PIEZOMETER SAMPLING.

1615 SECURED FOR DAY.

WORK COMPLETED: COLLECTED GROUNDWATER SAMPLES FROM SITE 1 WELLS AND PIEZOMETERS. DISCUSSED REMOVAL OF CANOPIES AND FILLING OF EXCAVATIONS WITH FRED CANSLER. SHIPPED SAMPLES TO ASC

[signature] 1/26/94

THURSDAY JANUARY 27, 1994

PROPOSED WORK FOR DAY: COMPLETE COLLECTION OF GROUNDWATER SAMPLES AT SITE 3 AND SHIP THE SAMPLES TO THE ASC. REMOVE THE CANOPIES COVERING THE EXCAVATIONS AT SITES 1 AND 3. PUMP THE WATER OUT OF THE EXCAVATIONS AT SITES 1 AND 3 AND SHIP THE WATER OFF SITE TO OSCO. BACKFILL THE EXCAVATION AT SITE 3. REMOVE THE DRUMS FROM THE ROLL OFF BOX AND TRANSFER THE DRUMS TO THE WAREHOUSE.

WEATHER ON SITE: CLOUDY AND COOL WITH A HIGH TEMPERATURE OF 45°F. WINDS VARIABLE 10-20 MPH.

E+E PERSONNEL ON SITE: O. JONES, J. MAYS, S. MCCUNE

LOG

0700 SCOTT MCCUNE ARRIVED AT SITE 3.

0710 ENVIROCHEM PERSONNEL ARRIVED AT SITE 3.

0715 HELD SITE SAFETY MEETING. DISCUSSED PHYSICAL AND CHEMICAL HAZARDS ASSOCIATED WITH SITE AND PROPOSED WORK FOR THE DAY.

0725 E+E SAMPLING TEAM ARRIVED ON SITE

 [signature] 1/27/94

1/27/94 RI6130

0730 E&E SAMPLING CREW COMMENCED COLLECTING SAMPLES AND PURGING MW3-1 AND MW3-2.

0800 FRED CANSLER ARRIVED ON SITE WITH PERSONNEL TO REMOVE THE CANOPY OVER THE EXCAVATION AT SITE 3. THE SUPPORTS WERE CUT AND THE CANOPY WAS DRAGGED AWAY FROM THE EXCAVATION WITH TWO TRACTORS.

0845 THE CANOPY REMOVAL AT SITE 3 COMPLETED AND THE CREW DEPARTED FOR SITE 1.

0850 COMMENCED PUMPING WATER FROM THE EXCAVATION INTO BRYSON TRAILER # 618C'S.

0915 THE E&E SAMPLING TEAM COMPLETED COLLECTING THE GROUNDWATER SAMPLES FROM MW3-1, MW3-2, MW3-3, AND MW3-4. COMMENCED PACKING SAMPLES.

0935 COMPLETED FILLING BRYSON TRAILER # 618CS WITH 5,000 GALLONS OF WATER AND PREPARED MANIFEST # 00941 FOR LOAD. COMMENCED LOADING BRYSON TRAILER # 429.

1000 E&E SAMPLING TEAM DEPARTED THE SITE TO DELIVER SAMPLES TO FEDERAL EXPRESS.

1030 ARRIVED AT SITE 1. THE CANSLER CREW IS IN THE PROCESS OF REMOVING THE CANOPY OVER THE EXCAVATION. CANOPY IS NOT MOVING AS A UNIT.

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RI 6130 1/27/94

1045 RETURNED TO SITE 3. ALL WATER IN THE EXCAVATION HAS BEEN REMOVED EXCEPT FOR THE ICE. BRYSON TRAILER # 429 LOADED WITH 5,200 GALLONS OF WATER. PREPARED MANIFEST # 00942 FOR LOAD. BOTH TRAILERS DEPARTED THE SITE.

1100 ENVIRONICS PERSONNEL OPENED THE DRUMS OF DRILLING FLUIDS, DEVELOPMENT WATER AND PURGE WATER AND FOUND THE DRUMS FULL OF ICE. ENVIRONICS WILL CONTACT GARY SHOCKLEY AND RECOMMEND THAT THE DRUMS OF LIQUIDS BE TRANSPORTED TO OSCO FOR TREATMENT SINCE THEY CAN NOT BE BULKED.

1200 CANSLER CREW COMMENCED LOADING TRUCKS WITH STONE FROM THE SITE WEST OF THE WOODEN NICKEL.

1230 ARRIVED AT THE SITE WHERE THE STONE WAS BEING LOADED. THE FILL MATERIAL IS ALL UNDISTURBED WEATHERED BEDROCK.

1245 ARRIVED AT SITE 3. TWO LOADS OF ROCK FILL HAVE BEEN DUMPED IN THE EXCAVATION; AN ESTIMATED FOUR MORE LOADS OF STONE WILL BE NEEDED TO FILL THE EXCAVATION.

1300 ARRIVED AT SITE 1. BRYSON TRAILER # 617

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TITLE: FIELD ACTIVITY LOGBOOKS

CATEGORY: DOC 2.1

REVISED: April 1998

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Title:	SEDIMENT SAMPLING
Category:	ENV 3.8
Revised:	March 1998

STANDARD OPERATING PROCEDURE

SEDIMENT SAMPLING

ecology and environment, inc.
368 Pleasant View Drive / Lancaster, New York 14086 / (716) 684-8060

TITLE:	SEDIMENT SAMPLING		
CATEGORY:	ENV 3.8	REVISED:	March 1998

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Section Page

1. Introduction

This Standard Operating Procedure (SOP) describes the procedures for the collection of representative sediment samples. Analysis of sediment samples may determine whether concentrations of specific pollutants exceed established threshold action levels, and whether the concentrations of pollutants present a risk to public health, welfare, or the environment.

2. Scope

Included in this discussion are procedures for obtaining representative samples, quality assurance measures, proper documentation of sampling activities, and recommendations for personnel safety.

3. Method Summary

Sediment samples may be recovered using a variety of methods and equipment. These are dependent on 1) the depth of the water in which the samples will be collected; 2) the sediment's characteristics; 3) the volume of sediment required; and 4) the type of sample required (disturbed or undisturbed). Ultimately, the type of sampling device used should be consistent with the objective of the study.

Near-surface sediment samples may be collected using a scoop or spoon (if near shore or in shallow water), or sediment dredge or grab sampler (if in deeper water). To obtain other than surficial sediment samples, core samplers or split-spoon samplers are required.

All sampling devices should be cleaned using pesticide-grade acetone (assuming that acetone is not a target compound) or methanol, rinsed with distilled water, wrapped in aluminum foil, and custody sealed for identification. The sampling equipment should remain in this wrapping until needed. Each sampler should be used for one sample only. However, dedicated samplers may be impractical if there are a large number of sediment samples to be collected. In this case, samplers should be cleaned in the field using the decontamination procedures outlined in E & E's *Equipment Decontamination* SOP.

4. Sample Preservation, Containers, Handling, and Storage

The chemical preservation of sediments is not generally recommended. Refrigeration is usually the best approach, supplemented by a minimal holding time. Sediment samples should be handled according to standard techniques and project-specific requirements as detailed in project work/sampling plans and quality assurance project plans.

5. Potential Problems

Potential problems with sediment sampling include cross-contamination of samples and improper sample collection. Cross-contamination problems may be eliminated or minimized through the use of dedicated sampling equipment and bottles. If this is not possible or practical, then proper decontamination of sampling equipment is necessary. Improper sample collection can involve using inadequate or inappropriate sampling devices, contaminated equipment, disturbance of the matrix resulting in compaction of the sample, and inadequate homogenization of the sample where required, resulting in variable, nonrepresentative results.

6. Equipment

The following is a list of equipment and items typically used for sediment sampling:

- Sampling plan,
- Sample location map,
- Safety equipment, as specified in the health and safety plan,
- Compass,
- Survey equipment,
- Tape measure,
- Camera,
- Four-ounce and eight-ounce glass jars with teflon liners,

- 40-ml glass vials with teflon-backed septum,
- Plastic bags for sample jars,
- Logbook,
- Labels,
- Waterproof ink pen,
- Chain-of-custody forms,
- Shipping cooler,
- Decontamination supplies and equipment, as described in the work plan,
- Canvas or plastic sheeting,
- Stainless-steel scoops,
- Stainless-steel spoons,
- Stainless-steel mixing bowls, or pans,
- Hand-driven split-spoon sampler,
- Shovel,
- Stainless-steel hand auger,
- Sediment dredge/grab sampler,
- Manual, gravity, or mechanical coring devices, and
- Teflon beaker attached to a telescoping pole.

7. Reagents

Sediment sampling does not require the use of reagents except for decontamination of equipment. Refer to E & E's *Equipment Decontamination* SOP and the site-specific work plan for proper decontamination procedures and appropriate solvents.

8. Procedures

8.1 Office Preparation

- Prepare a sampling plan in accordance with contract requirements. Conduct a literature and information search and review available background information (e.g., topographic maps, soil survey maps, geological survey maps, other site reports, etc.) to determine the extent of the sampling effort, the sampling methods to be employed, and the type and amounts of equipment and supplies required.
- E & E corporate policy requires that a health and safety plan be prepared prior to commencing any sampling activity. The plan must be approved and signed by the corporate health and safety officer or his/her designee (e.g., the regional safety coordinator [RSC]).
- Obtain necessary sampling and monitoring equipment (see Section 6), and ensure that everything is in working order.
- Contact delivery service to confirm ability to ship all equipment and samples. Determine whether shipping restrictions exist.
- Prepare schedules and coordinate with staff, clients, property owners, and regulatory agencies, if appropriate.

8.2 Field Preparation

- Identify local suppliers of sampling expendables and overnight delivery services (e.g., Federal Express).
- Decontaminate or preclean all equipment before sediment sampling, as described in E & E's *Equipment Decontamination* SOP, or as deemed necessary.
- Calibrate all health & safety monitoring equipment daily.
- A general site survey should be performed prior to site entry, in accordance with the health and safety plan. A site safety meeting identifying physical and chemical hazards should be conducted prior to sampling activities.
- Identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All lo-

cations must be cleared of utilities by the property owner or utility companies prior to sediment sampling.

8.3 Sample Collection

Numerous techniques and sampling devices may be employed to collect representative sediment samples. A number of sampling-related factors can contribute to the loss of sample integrity, including washout of fine-grained sediments during retrieval; compaction due to sample wall friction; and sampling vessel- or person-induced disturbance of surficial layers. Choosing the most appropriate sediment sampler for a study will depend on the sediment's characteristics, the volume and efficiency required, and the objectives of the study.

Most samples will be grab samples, although occasionally, sediment taken from various locations may be combined into one composite sample to reduce the amount of analytical support required.

The following procedure is used to collect surface sediment samples from small, low-flowing streams or near the shore of a pond or lake:

1. The sampler should select the sampling location furthest downstream for the first sample and work upstream. This will reduce the potential for disturbed sediments from migrating down to unsampled locations. This technique will also reduce the chances of cross-contaminating subsequent samples by sampling first in areas of suspected low contamination and working to the suspected higher concentration areas.

2. Using a precleaned, stainless-steel scoop, spoon, or other appropriate device, remove the required volume of sediment from the desired surface interval (e.g., 0-inch to 6-inch), place the sample in the appropriate precleaned glass jar, decant excess liquid as necessary, and secure the teflon-lined lid to the jar. If the sample is to be a composite sample, or if the sample is to be homogenized, the sediment is first placed in a stainless-steel mixing bowl and is homogenized prior to placement in the glass sample container. Samples for volatile organic analysis are not homogenized. Samples are handled in accordance with project-specific requirements.

3. Carefully and clearly identify the jar with the appropriate sample label, ensuring that all the categories or parameters listed in Section 10.1.1 have been addressed. Place a custody seal on the jar and lid, secure the seal in place with clear tape, and refrigerate the sample. The clear tape should also cover the jar's label.

4. Use the chain-of-custody form to document the types and number of sediment samples collected for shipment to a laboratory for analyses.

5. In the field logbook record the time and date of sample collection, as well as a description of the sample and any associated air monitoring measurements.

6. Decontaminate sampling equipment in accordance with E & E's *Equipment Decontamination* SOP.

The following procedure is used to collect subsurface sediment samples from small, low-flowing streams or near the shore of a pond or lake:

1. The sampler should select the sampling location farthest downstream for the first sample and work upstream. This will reduce the potential for disturbed sediments from migrating downstream to unsampled locations, and will also reduce the chances of cross-contaminating subsequent samples.

2. Using a precleaned split-spoon sampler or other hollow coring device, drive the sampler to the required depth with a smooth continuous motion. Remove the coring device by rotating and lifting it in a single smooth motion until the sampler is free from the sediment.

3. Before the sediment sample can be removed from the sampling device, the overlying water must be removed from the sampler by slowly pouring or siphoning it off near one side of the sampler. Care should be taken to ensure that the sediments are not disturbed, and that the fine-grained surficial sediment and organic matter are not lost while removing the overlying water.

4. Disassemble the split-spoon sampler by placing pipe wrenches on either end of the sampler. Remove both ends and open the split spoon with a precleaned stainless-steel spoon. Recover the sediment core from a core tube by pushing the sample out with a precleaned stainless-steel spoon.

5. Collect the necessary sample by cutting the core with the handle of a precleaned stainless-steel spoon, placing the sample in the appropriate precleaned glass jar, and securing the teflon-lined lid to the jar. Samples are handled in accordance with project-specific requirements.

6. Carefully and clearly label the jar with the appropriate sample tag, ensuring that all of the categories or parameters listed in Section 10.1.1 have been addressed. Place a custody seal on the jar and lid, and secure the seal in place with clear tape.

7. Use the chain-of-custody form to document the types and number of sediment samples collected and logged.

8. Record the time and date of sample collection, as well as a description of the sample and any associated air monitoring measurements, in the field logbook.

9. Decontaminate sampling equipment as per E & E's *Equipment Decontamination* SOP.

The following procedure is used to collect surface samples from rivers or from deeper lakes and ponds:

1. The sampler should select the sampling location farthest downstream for the first sample and work upstream. This will reduce the potential for disturbed sediments to migrate downstream to unsampled locations.

2. Using a precleaned sediment dredge or grab sampler, lower the sampler to the sediment layer with a polypropylene rope. Depending on the type of sampler used, the jaws of the sediment dredge will either automatically close, or will be triggered with a weighted messenger.

3. Recover the sampler and empty the sediment sample into a precleaned stainless-steel bowl. The water layer should be decanted slowly until only sediment remains in the bowl.

4. Using a precleaned stainless-steel spoon, remove the required volume of sediment. Place the sample in the appropriate precleaned glass jar, and secure the Teflon-lined lid to the jar.

5. Carefully and clearly identify the jar with the appropriate sample label, ensuring that all of the categories or parameters listed in Section 10.1.1 have been addressed. Place a custody seal on the jar and lid, and secure the seal in place with clear tape. The clear tape should cover the sample label.

6. Use the chain-of-custody form to document the types and number of sediment samples collected for shipment to a laboratory for analyses.

7. Record the time and date of sample collection, as well as a description of the sample and any associated air monitoring measurements, in the field logbook.

8. Decontaminate sampling equipment in accordance with E & E's *Equipment Decontamination* SOP.

The following procedure is used to collect subsurface samples from rivers or from deeper lakes and ponds:

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1. The sampler should select the sampling location farthest downstream for the first sample and work upstream. This will reduce the potential for disturbed sediments to migrate downstream to unsampled locations.

2. Attach a precleaned gravity or mechanical coring device to the required length of polypropylene sample line and allow the corer to freefall through the water to the bottom.

3. Determine the depth of sediment penetration, and if acceptable, retrieve the corer with a smooth, continuous lifting motion.

4. Remove the overlying water from the corer by slowly pouring or siphoning it off near one side of the sampler. Remove the nosepiece from the corer, and slide the sample out of the corer into a stainless-steel bowl or tray.

5. Collect the necessary sample by cutting the core with the handle of a stainless-steel spoon, placing the sample in the appropriate precleaned glass jar, and securing the teflon-lined lid to the jar. Samples are handled in accordance with project-specific requirements.

6. Carefully and clearly label the jar with the appropriate sample tag, ensuring that all of the categories or parameters listed in Section 10.1.1 have been addressed. Place a custody seal on the jar and lid, and secure the seal in place with clear tape.

7. Use the chain-of-custody form to document the types and number of sediment samples collected for shipment to a laboratory for analyses.

8. Record the time and date of sample collection, as well as a description of the sample and any associated air monitoring measurements, in the field logbook.

9. Decontaminate sampling equipment in accordance with E & E's *Equipment Decontamination* SOP.

8.4 Postoperations

1. Decontaminate all equipment according to E & E's *Equipment Decontamination* SOP prior to shipping the equipment back to the warehouse.

2. Organize field notes into the report format required by E & E's *Field Report Preparation* SOP. Logbooks should be maintained according to E & E's *Field Activities Log Book* SOP.

3. All samples should be shipped on the same day that they were collected to arrive at the laboratory not more than 24 hours after the samples were collected in accordance with E & E's *Sample Packaging* SOP.

9. Calculations

There are no specific calculations required for sediment sampling.

10. Quality Assurance

10.1 Sample Documentation

10.1.1 Sediment Sample Label

All sediment samples shall be documented in accordance with standard labeling techniques and project-specific requirements. The sediment sample label is completed to the fullest possible extent, prior to collecting the sample, and should contain the following minimum information:

- Site name or identification;
- Sample location and identifier;
- Date sample was collected in a day, month, year format (e.g., 03 JUN 91 for June 3, 1991);
- Time of sample collection, using 24-hour clock in the hours: minutes format; and
- Analysis required.

10.1.2 Logbook

A bound field logbook will be maintained by field personnel to record daily activities in accordance with E & E's *Field Activities Logbooks* SOP and include sample collection, tracking, and shipping information. A separate entry will be made for each sample collected. These entries should include information from the sample label and a complete description of the location from which the sediment sample was collected.

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10.1.3 Chain-of-Custody

Use the chain-of-custody form to document the types and number of sediment samples collected and logged.

10.2 Sampling Plan Design

- Many of the activities critical to ensuring that the collected samples are of high quality take place in the pre-collection planning and preparation stage. Careful planning and attention to detail at this stage will result in a more successful sampling effort, and will ensure collection of the highest quality samples possible. Since site and sampling conditions vary widely, and no universal sampling procedure can be recommended, a detailed sampling plan, consistent with the objectives of the study, must be developed prior to any sampling activities.

- Any of the sampling methods described here should allow a representative sediment sample to be obtained if the sampling plan is properly designed.

- Consideration must also be given to the collection of a sample representative of all horizons present in the sediment. Selection of the proper sampling device will facilitate this procedure.

- A stringent quality assurance project plan (QAPP) should be outlined before any sampling operation is attempted. This should include, but not be limited to, the use of properly cleaned samplers and sample containers, chain-of-custody procedures, and collection of quality assurance samples such as field blanks, trip blanks, and duplicate samples.

11. Data Validation

The data generated will be reviewed according to quality assurance (QA) considerations identified in Section 10.

12. Health and Safety

Depending on site-specific contaminants, various protective programs must be implemented prior to sediment sampling. The site safety plan should be reviewed with specific emphasis placed on a protection program planned for direct contact tasks. Standard safe operating practices should be followed, including minimizing contact with potential contaminants in both vapor and solid matrix by using both respirators and disposable clothing.

Use appropriate safe work practices for the type of contaminant expected (or determined from previous sampling efforts):

Particulate or Metals Contaminants

- Avoid skin contact with and incidental ingestion of dust. Wash hands and other exposed skin areas routinely.
- Use protective gloves when collecting and handling the sediment samples.

Volatile Organic Contaminants

- Hexane acts as a carrier for a number of semivolatile organic compounds. The presence of hexane vapors in the air while decontaminating samplers indicates that the potential for exposure exists.
- If monitoring results indicate the presence of organic vapors, sampling activities must be conducted in Level C protection.
- Acetone can penetrate some types of surgical gloves; use the appropriate gloves, such as Scorpio neoprene gloves, when handling acetone.

13. References

American Society for Testing and Materials, 1993, ***ASTM Standards on Aquatic Toxicology and Hazard Evaluation***, Philadelphia, PA, ASTM Publication Code Number (PCN): 03-547093-16.

Burton, G. Allen, 1992, ***Sediment Toxicity Assessment***, Chelsea, MI.

Great Lakes National Program Office, 1985, ***Methods Manual for Bottom Sediment Sample Collection***, United States Environmental Protection Agency, Chicago, Illinois, EPA-905/5-85-004.

Municipal Environmental Research Laboratory, 1980, ***Samplers and Sampling Procedures for Hazardous Waste Streams***, United States Environmental Protection Agency, Cincinnati, Ohio EPA-600/280-018.

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National Enforcement Investigations Center, 1980, ***Enforcement Considerations for Evaluations of Uncontrolled Hazardous Waste Sites by Contractors***, United States Environmental Protection Agency Office of Enforcement, Denver, Colorado.

Pacific Northwest Laboratories, 1987, ***Guidance for Sampling of and Analyzing for Organic Contaminants in Sediments***, United States Environmental Protection Agency, Criteria and Standards Division, Richland, Washington.

United States Department of Commerce, National Technical Information Service, 1985, ***Sediment Sampling Quality Assurance User's Guide***, Nevada University, Las Vegas, NV.

Title:	SAMPLE PACKAGING
Category:	ENV 3.16
Revised:	August 2008

STANDARD OPERATING PROCEDURE

SAMPLE PACKAGING

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1. Introduction

Liquid and solid environmental samples are routinely collected by E & E during field surveys, site investigations, and other site visits for laboratory analysis. Unless the samples have anesthetic, noxious, or other properties that could inhibit the ability of a flight crew member to perform his or her duty or are known to meet the established U.S. Department of Transportation criteria for hazardous material (i.e., explosive, corrosive, flammable, poisonous), they are not regulated as hazardous materials.

This Standard Operating Procedure (SOP) describes the packaging procedures to be used by E & E's staff to ensure the safe arrival of the samples at the laboratory for analyses. These procedures have been developed to reduce the risk of damage to the samples (i.e., breakage of the sample containers), promote the maintenance of sample temperature within the cooler, and prevent spillage of the sampled material should a container be broken.

In the event the sample material meets the established criteria of a DOT hazardous material, the reader is referred to E & E's Hazardous Materials/Dangerous Goods Shipping Guidance Manual (see H&S 5.5).

2. Scope

This SOP describes procedures for the packaging of environmental samples in:

- Coolers;
- Steel, aluminum and plastic drums; and
- 4GV fiberboard boxes.

The Hazardous Materials/Dangerous Goods Shipping Guidance Manual will complete the information needed for shipping samples by providing guidance on:

- Hazard determination for samples which meet the USDOT definition of a hazardous material;
- Shipping profiles for "standard" shipments;
- Shipping procedures for "non-standard" shipments;
- Marking of packages containing hazardous materials;
- Labeling of packages containing hazardous materials; and
- Preparation of shipping papers for hazardous materials shipment.

3. Sample Packaging Procedures

3.1 General

It is E & E's intent to package samples so securely that there is no chance of leakage during shipment. This is to prevent the loss of samples and the expenditure of funds for emergency responses to spills and the efforts necessary to re-obtain the sample.

Over the years, E & E has developed several "standard" package configurations for the shipping of environmental samples. These standard package configurations are described below.

Liquid samples are particularly vulnerable. Because transporters (carriers) do not know the difference between a package leaking distilled water and a package leaking a hazardous chemical, they will react to a spill in an emergency fashion, potentially causing enormous expense to E & E for the cleanup of the sample material. Therefore, liquids are to be packed in multiple layers of plastic bags and absorbent/cushioning material to preclude any possibility of leaks from a package. This section defines the standard packaging configurations for environmental samples.

3.2 Liquid Environmental Sample Packaging Procedures

Liquid environmental samples should be collected and preserved as outlined in the Standard Operating Procedures (SOP) for Surface Water Sampling (ENV 3.12), and Groundwater Well Sampling (ENV 3.7). ***Preserved water samples are not considered to meet the HM/DG definitions of Class 8 (Corrosive) due to the preservative and are therefore considered to be nonhazardous samples.*** Liquid environmental samples may be shipped using an 80-quart cooler or an outer package consisting of either a steel or aluminum drum. Because the steel and aluminum drums provide little insulating capability, they should not be used for samples that require icing.

Packaging Liquid Environmental Samples Using the 80-Quart Cooler

- Label and seal all water sample bottles according to appropriate sampling SOPs;
- Secure the bottle caps using fiberglass tape; and
- Place each amber, poly, and volatile organic analysis (VOA) bottle in a sealable plastic bag. Mark the temperature blank VOA bag for identification.

If a foam block insert is used:

- Line the cooler with two plastic bags;
- Place a foam insert (with holes cut to receive the sample bottles) inside the plastic bag;

- Place the bottles in the holes in the foam block;
- Fill void spaces with bagged ice to the top of the cooler;
- Fold over the plastic bags lining the cooler and secure shut with tape;
- Place Chain-of-Custody (C-O-C) form in a sealable bag and tape it to the inside of the cooler lid; and
- Secure the cooler with strapping tape and custody seal. Cover the custody seals with clear tape.

If acceptable absorbent material is used:

- Place 1 inch of inert absorbent material in the bottom of the cooler;
- Line the cooler with two plastic bags;
- Place each sample bottle inside the inner bag;
- Fill the void spaces around the bottles with absorbent to about half the height of the large bottles;
- Fill the remainder of the void spaces with bagged ice to within 4 inches of the top of the cooler, making sure the VOAs are in direct contact with a bag of ice;
- Fold over the plastic bags lining the cooler and secure shut with tape;
- Fill the remaining space in the cooler with absorbent to the top of the cooler;
- Place C-O-C form in a sealable bag and tape it to the inside of the cooler lid; and
- Secure the cooler with strapping tape and custody seal. Cover the custody seals with clear tape.

Note: Acceptable absorbent materials must not react dangerously with the liquid and include vermiculite only if certified asbestos free.

Alternate Packaging Using 1A2/1B2 Drum

- Place 3 inches of inert absorbent material in the bottom of the drum;
- Line the drum with two plastic bags;
- Place each sample bottle inside the inner bag;

- Fill the void spaces around the bottles with absorbent to the height of the larger bottles;
- Fold over the plastic bags lining the drum and secure shut with tape;
- Fill the remaining space in the drum with absorbent to the top of the drum;
- Place C-O-C form in a sealable bag and tape it to the inside of the drum lid; and
- Secure the drum with closing ring and apply custody seals. Cover the custody seals with clear tape.

3.3 Soil/Sediment Environmental Sample Packaging Procedures

Soil/sediment environmental samples should be collected as outlined in the SOP for Soil Sampling (ENV 3.13), and SOP for Sediment Sampling (ENV 3.8). Soil/sediment environmental samples may be shipped using an 80-quart cooler, a 4GV fiberboard combination package, or an outer package consisting of either a steel or aluminum drum. Because the steel and aluminum drums provide little insulating capability, they should not be used for samples that require icing.

Packaging Soil/Sediment Environmental Samples

- Label and seal each sample container according to SOPs;
- Secure the bottle caps using fiberglass tape;
- Place each sample bottle inside a sealable plastic bag and place it in its original shipping box or in individual fiberboard boxes. Mark the temperature blank bag for identification; and
- Secure the original shipping box with strapping tape, place shipping box in a plastic bag, and secure the plastic bag with tape.

If an 80-quart cooler is used:

- Place bubble pack or similar material on the bottom and sides of an 80-quart cooler;
- Place the bagged shipping boxes in the cooler with a layer of bubble pack between each box;
- Fill the void spaces with "blue ice" or ice in baggies to the top of the cooler;
- Place C-O-C form in a sealable baggie and tape it to the inside of the cooler lid; and

- Secure the cooler with strapping tape and custody seal. Cover the seals with clear tape.

If a 1A2/1B2 drum is used:

- Place 3 inches of inert absorbent material in the bottom of the drum;
- Line the drum with two plastic garbage bags;
- Place the boxes inside the inner bag;
- Fill the space around the samples with absorbent;
- Fold over the plastic bags lining the drum and secure shut with tape;
- Fill the remaining space around the bags with absorbent to the top of the drum;
- Place C-O-C form in a sealable bag and tape it to the inside of the drum lid; and
- Secure the drum with the closing ring and apply custody seals. Cover the custody seals with clear tape.

Note: If a small number of samples are being shipped, it may be more practical to package them using the absorbent or foam block configurations used for shipping liquid samples.

4. Shipping Procedures

Environmental samples are to be shipped as nonhazardous cargo. Unless the samples have anesthetic, noxious, or other properties that could inhibit the ability of a flight crew member to perform his or her duty or are known to meet the established U.S. Department of Transportation criteria for a hazardous material (i.e., explosive, corrosive, flammable, poisonous), they are not regulated as hazardous materials. When preparing the containers (i.e., cooler, drum, or box) for shipment, E & E staff must remove all labels from the outside container. Labels indicating that the contents may be hazardous are misleading and are not appropriate. Markings indicating ownership of the container, destination, and chain of custody labels are acceptable and can be attached as required.

When completing the paperwork for shipment, the standard nonhazardous forms must be used. Do not use the hazardous materials/dangerous goods airbills, either in total or in part; these forms are coded and their use will invite unnecessary questions. This will only serve to confuse DHL or Federal Express' terminal personnel and will cause much frustration and the delay of sample shipment.

Environmental sample packages can be shipped overnight by both DHL and Federal Express. When choosing between the two, cost should be considered. It is normally much cheaper to ship DHL. In addition, DHL tends to have remote locations open later in the evenings than Federal Express, which may be helpful when trying to complete a full day's sampling effort and still make the flights on time. Although both companies offer pickup of samples at the site, it is advisable to call ahead and ensure that this service is offered beforehand. In almost all cases, both companies will deliver to the laboratory of your choice on Saturdays. When planning for sampling activities, check with the companies in advance to verify pick-up and delivery schedules.

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Title:	SURFACE WATER SAMPLING
Category:	ENV 3.12
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STANDARD OPERATING PROCEDURE

SURFACE WATER SAMPLING

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1. Introduction

This Standard Operating Procedure (SOP) outlines recommended procedures and equipment for the collection of representative liquid samples (aqueous and nonaqueous) from streams, rivers, lakes, ponds, lagoons, and surface impoundments both at the surface and at various depths in the water column. This SOP does not pertain to the collection of groundwater samples.

2. Method Summary

Sampling situations vary widely and therefore, no universal sampling procedure can be recommended. A sampling plan must be completed before any sampling operation is attempted. The sampling plan should include objectives of the study, the number and type of samples required to meet these objectives, and procedures to collect these samples based on site characteristics.

The sampling of both aqueous and nonaqueous liquids from the above-mentioned sources is generally accomplished through the use of one of the following:

- Kemmerer bottle,
- Bacon bomb,
- Dip sampler, or
- Direct method.

These sampling techniques will allow for the collection of representative samples from the majority of surface water types and impoundments encountered.

3. Potential Problems

There are two primary potential problems associated with surface water sampling: cross-contamination of samples, and improper sample collection.

Cross-contamination problems can be eliminated or minimized through the use of dedicated sampling equipment and bottles. If this is not possible or practical, then decontamination of sampling equipment is necessary. See E & E's SOP on *Equipment Decontamination* (ENV 3.15).

Improper sample collection can involve using contaminated equipment, disturbance of stream or impoundment substrate, and sampling in a disturbed area such as that caused by a boat wake. Following proper decontamination procedures and minimizing disturbance of the sample site will minimize or eliminate these problems.

4. Equipment

Equipment needed for collecting surface water samples includes:

- Kemmerer bottle,
- Bacon bomb,
- Dip sampler,
- Line and messengers,
- Sample bottles, preservative, ziploc bags, ice, coolers,
- Chain-of-custody seals and forms, field data sheets,
- Decontamination equipment,
- Protective clothing,
- Maps/plot plan,
- Safety equipment,
- Compass,
- Tape measure,
- Survey stakes, flags, or buoys and anchors,
- Camera and film,
- Logbook, and
- Sample bottle labels.

5. Reagents

Reagents are commonly used to preserve samples and to decontaminate sampling equipment. Appropriate preservation and decontamination procedures should be selected prior to field sampling.

Preservatives commonly used include:

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- Nitric acid (HNO_3) for metals analyses,
- Sodium hydroxide (NaOH) for cyanide analysis,
- Sulfuric acid (H_2SO_4) for TRPH analysis, and
- Hydrochloric acid (HCl) for VOC analysis.

Decontamination reagents include:

- Nitric acid (HNO_3),
- Acetone, and
- Deionized or distilled water.

6. Health and Safety

Personal safety is always the most important factor in any sampling operation. Sampling under unknown conditions should always be considered worst case, necessitating the selection of appropriate personal protection.

When sampling lagoons or surface impoundments containing known or suspected hazardous substances, adequate precautions must be taken to ensure the safety of sampling personnel. The sampling team member collecting the sample should not get too close to the edge of the impoundment, where bank failure may cause him/her to lose their balance. The person performing the sampling should be on a lifeline and wearing adequate protective equipment.

When conducting sampling from a boat in an impoundment or flowing waters, appropriate boating safety procedures will be followed.

7. Procedures

7.1 Sampling Considerations

7.1.1 Preparation

Prior to the initiation of any sampling operation, the immediate area should be checked for radioactivity, volatile organic compounds (VOCs), photoionization potential, airborne dust, and explosivity, as required by the Site Safety Plan. The following steps should then be taken:

- Determine the extent of the sampling effort, the sampling methods to be employed, and the equipment and supplies needed;

- Obtain necessary sampling and monitoring equipment;
- Decontaminate or preclean equipment, and ensure that it is in working order;
- Prepare scheduling and coordinate with staff, clients, and regulatory agency, if appropriate; and
- Use stakes, flags, or buoys and anchors to identify and mark all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions.

7.1.2 Representative Samples

In order to collect a representative sample, the hydrology and morphology of a stream or impoundment should be determined prior to sampling. This will aid in determining the presence of phases or layers in lagoons or impoundments, flow patterns in streams, and appropriate sample locations and depths. Additional information can be found in the references listed in Section 12.

Generally, the deciding factors in the selection of a sampling device for surface water sampling are:

- The depth and flow of surface water body,
- Location from where the sample will be collected, and
- The depth at which the sample(s) is to be collected.

7.1.3 Sampler Composition

The sampling device must be constructed of the appropriate materials. Samplers constructed of glass, stainless steel, PVC, or PFTE (teflon) should be used, depending on the types of analyses to be performed (i.e., samples to be analyzed for metals should not be collected in metallic containers).

7.2 Sample Collection

7.2.1 Kemmerer Bottle

A Kemmerer bottle may be used in most situations where site access is from a boat or structure such as a bridge or pier, and where samples at depth are required. Sampling procedures are as follows:

- Using a properly decontaminated Kemmerer bottle, set the sampling device so that the sampling end pieces are pulled away from the sampling tube, allowing the substance to pass through this tube;

- Slowly lower the preset sampling device to the predetermined depth. Avoid bottom disturbance;

- When the Kemmerer bottle is at the required depth, send down the messenger, closing the sampling device; and

- Retrieve the sampler. Transfer sample to sample container.

7.2.2 Bacon Bomb

This type of sampler may be used in situations similar to those outlined for the Kemmerer bottle. Sampling procedures are as follows:

- Lower the bacon bomb sampler carefully to the desired depth, allowing the line for the trigger to remain slack at all times. When the desired depth is reached, pull the trigger line until taut; and

- Release the trigger line and retrieve the sampler. Transfer the sample to the sample container by pulling on the trigger.

7.2.3 Dip Sampler

A dip sampler is useful for situations in which a sample is to be recovered from an outfall pipe, such as through a storm sewer grating, or along a lagoon bank where direct accessibility is limited. The long handle on such a device allows access from a discrete location. The procedure is as follows:

- Assemble the device in accordance with the manufacturer's instructions,

- Extend the device to the sample location and collect the sample, and

- Retrieve the sampler.

7.2.4 Direct Method

For streams, rivers, lakes, and other surface waters, the direct method may be utilized to collect water samples from the surface. This method is not to be used for sampling lagoons or other impoundments where contact with contaminants is a concern.

Using adequate protective clothing (i.e., gloves and hip waders), access the sampling station by appropriate means (wading or boat). For shallow stream stations, collect the sample under the water surface pointing the sample container upstream. The container must also be upstream of the collector. Avoid disturbing the substrate. For lakes and other impoundments, collect the sample under the water surface avoiding surface debris and the boat wake.

8. Sample Preservation, Containers, Handling, and Storage

Sample preservation, sample containers, sample handling, and sample storage are critical concerns for many types of analyses. Once the analyses to be performed are determined, E & E's SOP on sample packaging and shipping should be consulted to determine the above parameters. This must be completed prior to field sampling.

Once the samples have been collected, the following procedure should be followed:

- Transfer the sample(s) into suitable and labeled sample containers;
- Preserve the sample, if appropriate;
- Cap and put a custody seal on the container, package appropriately, and place in an iced cooler if required;
- Record all pertinent data in the field logbook and on a field data sheet;
- Complete chain-of-custody record and sample analysis request form;
- Attach custody seals to cooler prior to shipment; and
- Decontaminate all sampling equipment prior to the collection of additional samples.

9. Calculations

This procedure does not involve specific calculations.

10. Quality Assurance

There are no specific quality assurance (QA) activities that apply to the implementation of these procedures. However, the following general QA procedures apply:

- All data must be documented on field data sheets or within field or site logbooks;
- All instrumentation must be operated in accordance with operating instructions as supplied by the manufacturer unless otherwise specified in the work plan. Equipment

checkout and calibration activities must occur prior to sampling or operation and must be documented; and

- All deliverables will receive a peer review prior to release.

11. Data Validation

The data generated will be reviewed according to the QA considerations listed in Section 9.

12. References

U.S. Environmental Protection Agency, 1991, *Compendium of ERT Surface Water and Sediment Sampling Procedures*, Interim Final, OSWER Directive 9360.4-03.

__________, 1984, *Characterization of Hazardous Waste Sites - A Methods Manual: Volume II, Available Sampling Methods*, (2nd ed.), EPA/600/4-84-076.

U.S. Geological Survey, 1977, *National Handbook on Recommended Methods for Water Data Acquisition, Office of Water Data Coordination, Reston, Virginia.*

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STANDARD OPERATING PROCEDURE

SOIL SAMPLING

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LIST OF FIGURES

1. Introduction

This document describes the procedures for the collection of representative soil samples. Representative sampling ensures the accurate characterization of site conditions. Analysis of soil samples may determine pollutant concentrations and the accompanying risks to public health, welfare, or the environment.

2. Scope

Included in this discussion are procedures for obtaining representative samples, quality assurance/quality control (QA/QC) measures, proper documentation of sampling activities, and recommendations for personnel safety.

3. Method Summary

Soil samples may be recovered using a variety of methods and equipment. These are dependent on the depth of the desired sample, the type of sample required (disturbed vs. undisturbed), and the soil type.

Samples of near-surface soils may be easily obtained using a spade, stainless-steel spoon, trowel, or scoop. Sampling at greater depths may be performed using a hand auger; a power auger; or, if a test pit is required, a backhoe.

All sampling devices should be cleaned using pesticide-grade acetone (assuming that acetone is not a target compound) or methanol, then wrapped in clean aluminum foil, and custody sealed for identification. The sampling equipment should remain in this wrapping until it is needed. Each sampler should be used for one sample only. However, dedicated tools may be impractical if there is a large number of soil samples required. In this case, samplers should be cleaned in the field using standard decontamination procedures as outlined in E & E's Standard Operating Procedure (SOP) for Sampling Equipment Decontamination (see ENV 3.15).

4. Sample Preservation, Containers, Handling, and Storage

The chemical preservation of solids is not generally recommended. Refrigeration is usually the best approach, supplemented by a minimal holding time.

Soil samples should be handled according to the procedures outlined in E & E's SOP for Sample Packaging (see ENV 3.16).

5. Potential Problems

Potential problems with soil sampling include cross-contamination of samples and improper sample collection. Cross-contamination problems can be eliminated or minimized through the use of dedicated sampling equipment and bottles. If this is not possible or practical, then decontamination of sampling equipment is necessary. Improper sample collection is generally the result of the use of contaminated equipment; the disturbance of the matrix, resulting in compaction of the sample; and inadequate homogenization of the sample where required, resulting in variable, nonrepresentative results. Specific advantages and disadvantages of soil sampling equipment are presented in Table 5-1.

Table 5-1 Soil Sampling Equipment

Equipment	Applicability	Advantages and Disadvantages
Trier	Soft surface soil	Inexpensive; easy to use and decontaminate; difficult to use in stony, dry, or sandy soil.
Scoop, trowel, spoon, or spatula	Soft surface soil	Inexpensive; easy to use and decontaminate; trowels with painted surfaces should be avoided.
Tulip bulb planter	Soft soil, 0 to 6 inches	Easy to use and decontaminate; uniform diameter and sample volume; preserves soil core (suitable for volatile organic analysis (VOA) and undisturbed sample collection); limited depth capability; not useful for hard soils.
Spade or shovel	Medium soil, 0 to 12 inches	Easy to use and decontaminate; inexpensive; can result in sample mixing and loss of volatile organic compounds (VOCs).
Vehimeyer soil outfit	Soil, 0 to 10 feet	Difficult to drive into dense or hard material; can be difficult to pull from ground.
Soil coring device and auger	Soft soil, 0 to 24 inches	Relatively easy to use; preserves soil core (suitable for VOA and undisturbed sample collection); limited depth capability; can be difficult to decontaminate.
Thin-walled tube sampler	Soft soil, 0 to 10 feet	Easy to use; preserves soil core (suitable for VOA and undisturbed sample collection); may be used to help maintain integrity of VOA samples; easy to decontaminate; can be difficult to remove cores from sampler.
Split-spoon sampler	Soil, 0 inches to bedrock	Excellent depth range; preserves soil core (suitable for VOA and undisturbed sample collection); acetate sleeve may be used to help maintain integrity of VOA samples; useful for hard soils; often used in conjunction with drill rig for obtaining deep cores.

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Table 5-1 Soil Sampling Equipment

Equipment	Applicability	Advantages and Disadvantages
Shelby tube sampler	Soft soil, 0 inches to bedrock	Excellent depth range; preserves soil core (suitable for VOA and undisturbed sample collection); tube may be used to ship sample to lab undisturbed; may be used in conjunction with drill rig for obtaining deep cores and for permeability testing; not durable in rocky soils.
Laskey sampler	Soil, 0 inches to bedrock	Excellent depth range; preserves soil cores; used in conjunction with drill rig for obtaining deep core; can be difficult to decontaminate.
Bucket auger	Soft soil, 3 inches to 10 feet	Easy to use; good depth range; uniform diameter and sample volume; acetate sleeve may be used to help maintain integrity of VOA samples; may disrupt and mix soil horizons greater than 6 inches in thickness.
Hand-operated power auger	Soil, 6 inches to 15 feet	Good depth range; generally used in conjunction with bucket auger for sample collection; destroys soil core (unsuitable for VOA and undisturbed sample collection); requires two or more equipment operators; can be difficult to decontaminate; requires gasoline-powered engine (potential for cross-contamination).
Continuous-flight auger	Soil, 0 inches to bedrock	Excellent depth range; easy to decontaminate; can be used on all soil samples; results in soil mixing and loss of VOCs.
Dutch auger	Designed specifically for wet, fibrous, or rooted soils (e.g., marshes)	
Eijkelcamp stoney soil auger	Stoney soils and asphalt	
Backhoe	Soil, 0 inches to 10 feet	Good depth range; provides visual indications as to depth of contaminants; allows for recovery of samples at specific depths; can result in loss of VOCs and soil mixing; shoring required at depth.

Note: Samplers may not be suitable for soils with coarse fragments.
Augers are suitable for soils with limited coarse fragments; only the stoney auger will work well in very gravelly soil.

6. Soil Sampling Equipment

Soil Sampling Equipment List

- Stainless-steel spoon
- Trier
- Scoop
- Trowel

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- Spatula
- Stainless-steel tulip bulb planter
- Spade or shovel
- Vehimeyer soil sampler outfit
  - tubes
  - points
  - drive head
  - drop hammer
  - fuller jack and grip
- Soil-coring device
- Thin-walled tube sampler
- Split-spoon sampler
- Shelby tube sampler
- Laskey sampler
- Bucket auger
- Hand-operated power auger
- Continuous-flight auger
- Dutch auger
- Eijkelcamp stoney soil auger
- Backhoe
- Hand auger with replaceable sleeves

Sampling Support Equipment and Documentation List

- Sampling plan
- Sample location map
- Safety equipment, as specified in the Health and Safety Plan
- Decontamination supplies and equipment, as described in the Work Plan
- Compass
- Tape measure
- Survey stakes or flags
- Camera
- Stainless-steel buckets or bowls
- Sample containers, precleaned (e.g., I-Chem)
- Logbook
- Chain-of-custody forms
- Plastic sheet
- Soil gas probes
- Infiltrometer
- Pounding sleeve
- Extension rods
- T-handle

Labeling, Packaging, and Shipping Supplies

- Coolers
- Labels for sample containers and coolers (e.g., "fragile")
- Ice
- Plastic bags for sample containers and ice
- ESC paint cans and clamps for polychlorinated biphenyl sampling
- Vermiculite (only if certified asbestos free) or other absorbent
- Duct and strapping tape
- Federal Express airbills and pouches

6.1 Geophysical Equipment

Geophysical techniques can be integrated with field analytical and soil sampling equipment to help define areas of subsurface contamination. For a description of the geophysical techniques and associated applications, refer to E & E's SOP for Surface Geophysical Techniques (see GEO 4.2).

7. Reagents

This procedures does not require the use of reagents except for decontamination of equipment, as required. Refer to E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15) and the Site-Specific Work Plan for proper decontamination procedures and appropriate solvents.

8. Procedures

8.1 Office Preparation

1. The preparation of a Health and Safety Plan is required prior to any sampling. The plan must be approved and signed by the Corporate Health and Safety Officer or his/her designee (i.e., the Regional Safety Coordinator).

2. Prepare a Sampling Plan to meet the data quality objectives of the project in accordance with contract requirements. Review available background information (i.e., topographic maps, soil survey maps, geologic maps, other site reports, etc.) to determine the extent of the sampling effort, the sampling method to be employed, and the type and amounts of equipment and supplies required.

3. Obtain necessary sampling and monitoring equipment (see Section 6), decontaminate or preclean the equipment, and ensure that it is in working order.

4. Contact the delivery service to confirm the ability to ship all equipment and samples. Determine whether shipping restrictions exist.

5. Prepare schedules and coordinate with staff, clients, and regulatory agencies, if appropriate.

8.2 Field Preparation

1. Identify local suppliers of sampling expendables (e.g., ice and plastic bags) and overnight delivery services (e.g., Federal Express).

2. Decontaminate or preclean all equipment before soil sampling, as described in E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15), or as deemed necessary.

3. A general site survey should be performed prior to site entry in accordance with the Health and Safety Plan, followed by a site safety meeting.

4. Identify and stake all sampling locations. If required, the proposed locations may be adjusted based on site access, property boundaries, and surface obstructions. All staked locations will be utility-cleared by the property owner or field team prior to soil sampling.

8.3 Representative Sample Collection

The objective of representative sampling is to ensure that a sample or group of samples adequately reflects site conditions.

8.3.1 Sampling Approaches

It is important to select an appropriate sampling approach for accurate characterization of site conditions. Each approach is defined below. Table 8-1 summarizes the following sampling approaches and ranks them from most to least suitable based on the sampling objective.

8.3.1.1 Judgmental Sampling

Judgmental sampling is based on the subjective selection of sampling locations relative to historical site information, on-site investigation (site walk-over), etc. There is no randomization associated with this sampling approach because samples are collected primarily at areas of suspected highest contaminant concentrations. Therefore, any statistical calculations based on the sampling results would be unfairly biased.

Table 8-1 Representative Sampling Approach Comparison

Sampling Objective	Judgmental	Random	Stratified Random	Systematic Grid	Systematic Random	Search	Transect
Establish Threat	1	4	3	2[a]	3	3	2
Identify Sources	1	4	2	2[a]	3	2	3
Delineate Extent of Contamination	4	3	3	1[b]	1	1	1
Evaluate Treatment and Disposal Options	3	3	1	2	2	4	2
Confirm Cleanup	4	1[c]	3	1[b]	1	1	1[c]

1 Preferred approach.
2 Acceptable approach.
3 Moderately acceptable approach.
4 Least acceptable approach.
a Should be used with field analytical screening.
b Preferred only where known trends are present.
c Allows for statistical support of cleanup verification if sampling over entire site.

8.3.1.2 Random Sampling

Random sampling involves the arbitrary collection of samples within a defined area. Refer to EPA 1984 and EPA 1989 for a random number table and guidelines on selecting sample coordinates. The arbitrary selection of sample locations requires each sample location to be chosen independently so that results in all locations within the area of concern have an equal chance of being selected. To facilitate statistical probabilities of contaminant concentration, the area of concern must be homogeneous with respect to the parameters being monitored. Thus, the higher the degree of heterogeneity, the less the random sampling approach will reflect site conditions (see Figure 8-1).

8.3.1.3 Stratified Random Sampling

Stratified random sampling relies primarily on historical information and prior analytical results to divide the area of concern into smaller sampling areas, or "strata." Strata can be defined by several factors, including sampling depth, contaminant concentration levels, and contaminant source areas. Sampling locations should be selected within a strata using random selection procedures (see Figure 8-2).

8.3.1.4 Systematic Grid Sampling

Systematic grid sampling involves the division of the area of concern into smaller sampling areas using a square or triangular grid. Samples are then collected from the intersections of the grid lines, or "nodes." The origin and direction for placement of the grid should be selected by using an initial random point. The distance between nodes is dependent upon the size of the area of concern and the number of samples to be collected (see Figure 8-3).

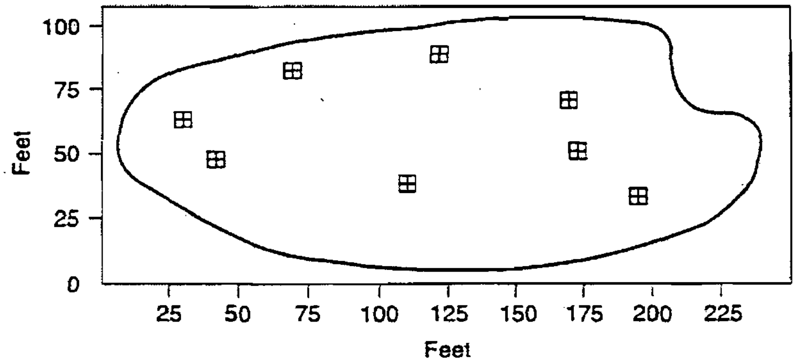


Figure 8-1 Random Sampling**

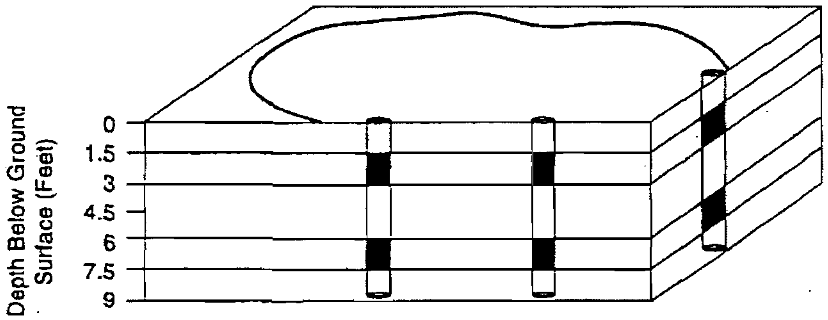


Figure 8-2 Stratified Random Sampling

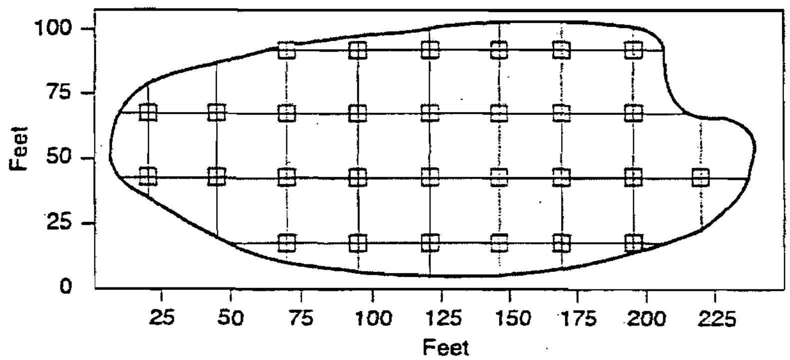
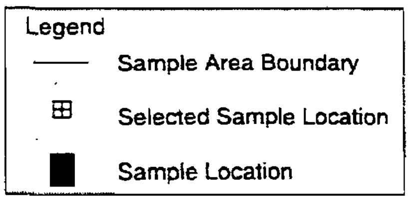


Figure 8-3 Systematic Grid Sampling**

** After EPA, February 1989



8.3.1.5 Systematic Random Sampling

Systematic random sampling involves dividing the area of concern into smaller sampling areas as described in Section 8.3.1.4. Samples are collected within each grid cell using random selection procedures (see Figure 8-4).

8.3.1.6 Biased-Search Sampling

Search sampling utilizes a systematic grid or systematic random sampling approach to define areas where contaminants exceed cleanup standards (i.e., hot spots). The distance between the grid lines and number of samples to be collected are dependent upon the acceptable level of error (i.e., the chance of missing a hot spot). This sampling approach requires that assumptions be made regarding the size, shape, and depth of hot spots (see Figure 8-5).

8.3.1.7 Transect Sampling

Transect sampling involves establishing one or more transect lines, parallel or nonparallel, across the area of concern. If the lines are parallel, this sampling approach is similar to systematic grid sampling. The advantage of transect sampling over systematic grid sampling is the relative ease of establishing and relocating transect lines as opposed to an entire grid. Samples are collected at regular intervals along the transect line at the surface and/or at a specified depth(s). The distance between the sample locations is determined by the length of the line and the number of samples to be collected (see Figure 8-6).

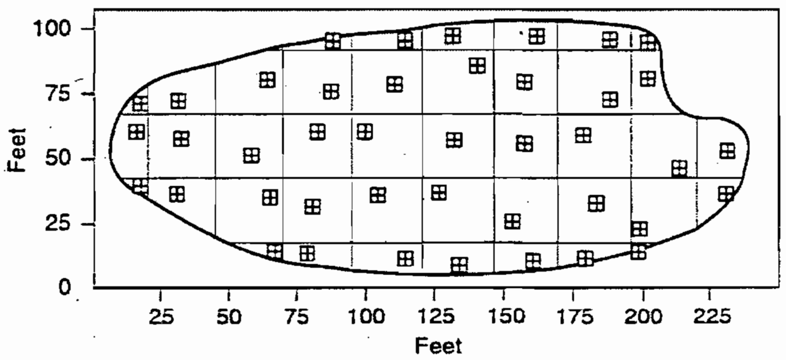


Figure 8-4 Systematic Random Sampling

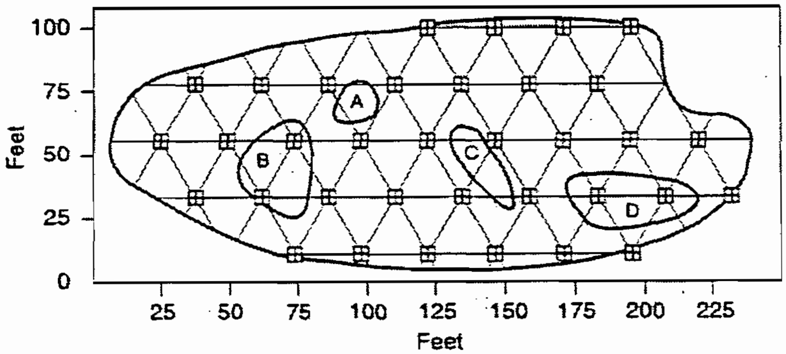


Figure 8-5 Search Sampling

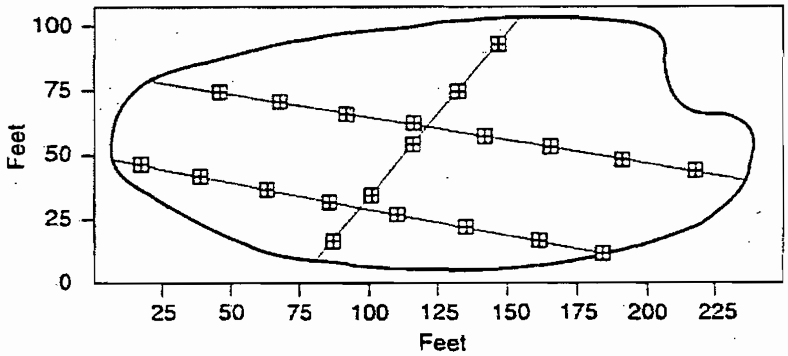


Figure 8-6 Transect Sampling

After EPA, February 1989

Legend
- *Sample Area Boundary*
- Selected Sample Location
- *Sample Location*

8.3.2 Surface Soil Samples

Collection of samples from near-surface soil can be accomplished with tools such as spades, spoons, shovels, and scoops. The surface material can be removed to the required depth with this equipment; stainless-steel or plastic scoops can then be used to collect the sample.

This method can be used in most soil types, but is limited to sampling near-surface areas. Accurate, representative samples can be collected with this procedure, depending on the care and precision demonstrated by the sampling technician. The use of a flat, pointed mason trowel to cut a block of the desired soil can be helpful when undisturbed profiles are required (e.g., for volatile organic analyses [VOAs]). A stainless-steel scoop, lab spoon, or plastic spoon will suffice in most other applications. Care should be exercised to avoid the use of devices plated with chrome or other materials, as is common with garden implements such as potting trowels.

Soil samples are collected using the following procedure:

1. Carefully remove the top layer of soil to the desired sample depth with a precleaned spade;

2. Using a precleaned, stainless-steel scoop, spoon, trowel, or plastic spoon, remove and discard the thin layer of soil from the area that came into contact with the shovel;

3. Transfer the sample into an appropriate container using a stainless-steel or plastic lab spoon or equivalent. If composite samples are to be collected, place the soil sample in a stainless-steel or plastic bucket and mix thoroughly to obtain a homogeneous sample representative of the entire sampling interval. Place the soil samples into labeled containers. (**Caution: Never composite VOA samples**);

4. VOA samples should be collected directly from the bottom of the hole before mixing the sample to minimize volatilization of contaminants;

5. Check to ensure that the VOA vial Teflon liner is present in the cap, if required. Fill the VOA vial fully to the top to reduce headspace. Secure the cap tightly. The chemical preservation of solids is generally not recommended. Refrigeration is usually the best approach, supplemented by a minimal holding time;

6. Ensure that a sufficient sample size has been collected for the desired analysis, as specified in the Sampling Plan;

7. Decontaminate equipment between samples according to E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15); and

8. Fill in the hole and replace grass turf, if necessary.

QA/QC samples should be collected as specified, according to the Work Plan.

8.3.3 Sampling at Depth with Augers and Thin-Walled Tube Samplers

This system consists of an auger, a series of extensions, a T-handle, and a thin-walled tube. The auger is used to bore a hole to a desired sampling depth and is then withdrawn. The auger tip is then replaced with a tube core sampler, lowered down the borehole, and driven into the soil to the completion depth. The core is then withdrawn and the sample is collected.

Several augers are available, including bucket type, continuous-flight (screw), and post-hole augers. Because they provide a large volume of sample in a short time, bucket types are better for direct sample recovery. When continuous-flight augers are used, the sample can be collected directly off the flights, usually at 5-foot intervals. The continuous-flight augers are satisfactory for use when a composite of the complete soil column is desired. Posthole augers have limited utility for sample collection because they are designed to cut through fibrous, rooted, swampy soil.

The following procedures will be used for collecting soil samples with the hand auger:

1. Attach the auger bit to a drill rod extension, and attach the T-handle to the drill rod.

2. Clear the area to be sampled of any surface debris (e.g., twigs, rocks, and litter). It may be advisable to remove the first 3 to 6 inches of surface soil from an area approximately 6 inches in radius around the drilling location.

3. Begin augering, periodically removing and depositing accumulated soils onto a canvas or plastic sheet spread near the hole. This prevents accidental brushing of loose material back down the borehole when removing the auger or adding drill rods. It also facilitates refilling the hole and avoids possible contamination of the surrounding area.

4. After reaching the desired depth, slowly and carefully remove the auger from the boring. When sampling directly from the auger, collect the sample after the auger is removed from the boring and proceed to Step 11.

5. A precleaned stainless-steel auger sleeve can also be used to collect a sample. After reaching the desired sampling depth, remove the auger and place the sleeve inside the auger. Collect the sample with the auger. Remove the auger from the boring. The sample will be collected only from the sleeve. The soil from the auger tip should never be used for the sample.

6. Remove the auger tip from the dill rods and replace with a precleaned thin-walled tube sampler. Install the proper cutting tip.

7. Carefully lower the tube sampler down the borehole. Gradually force the tube sampler into the soil. Care should be taken to avoid scraping the borehole sides. Avoid hammering the drill rods to facilitate coring, because the vibrations may cause the boring walls to collapse.

8. Remove the tube sampler and unscrew the drill rods.

9. Remove the cutting tip and core from the device.

10. Discard the top of the core (approximately 1 inch), because this represents material collected before penetration of the layer in question. Place the remaining core into the sample container.

11. If required, ensure that a Teflon liner is present in the cap. Secure the cap tightly onto the sample container. Place the sample bottle in a plastic bag and put on ice to keep the sample at 4°Celsius.

12. Carefully and clearly label the container with the appropriate sample tag, addressing all the categories or parameters listed in E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).

13. Use the chain-of-custody form to document the types and numbers of soil samples collected and logged. Verify that the chain-of-custody form is correctly and completely filled out.

14. Record the time and date of sample collection, as well as a description of the sample, in the field logbook.

15. If another sample is to be collected in the sample hole, but at a greater depth, re-attach the auger bit to the drill and assembly, and follow Steps 3 through 11, making sure to decontaminate the auger and tube sampler between samples.

16. Abandon the hole according to applicable regulations. Generally, shallow holes can simply be backfilled with the removed soil material.

17. Decontaminate the sampling equipment per E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15).

8.3.4 Sampling at Depth with a Trier

1. Insert the trier into the material to be sampled at a 0° to 45° angle from horizontal. This orientation minimizes the spillage of sample material. Extraction of samples may require tilting of the containers.

2. Rotate the trier once or twice to cut a core of material.

3. Slowly withdraw the trier, making sure that the slot is facing upward.

4. Transfer the sample into a suitable container with the aid of a spatula and brush.

5. If required, ensure that a Teflon liner is present in the cap. Secure the cap tightly onto the sample container. Samples are handled in accordance with E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).

6. Carefully and clearly label the container with the appropriate sample tag, addressing all the categories or parameters listed in E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).

7. Use the chain-of-custody form to document the types and numbers of soil samples collected and logged.

8. Record the time and date of sample collection as well as a description of the sample and any associated air monitoring measurements in the field logbook.

9. Abandon the hole according to applicable regulations. Generally, shallow holes can simply be backfilled with the removed soil material.

10. Decontaminate sampling equipment per E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15).

8.3.5 Sampling at Depth with a Split-Spoon (Barrel) Sampler

The procedure for split-spoon sampling describes the extraction of undisturbed soil cores of 18 or 24 inches in length. A series of consecutive cores may be sampled to give a complete soil column, or an auger may be used to drill down to the desired depth for sampling. The split spoon is then driven to its sampling depth through the bottom of the augured hole and the core extraction.

This sampling device may be used to collect information such as soil density. All work should be performed in accordance with American Society for Testing and Materials (ASTM) D 1586-84, *Penetration Test and Split Barrel Sampling of Soils.*

1. Assemble the sampler by aligning both sides of the barrel and then screwing the bit on the bottom and the heavier head piece on top. Install a retaining cap in the head piece if necessary.

2. Place the sampler in a perpendicular position on the sample material.

3. Using a sledge hammer or well ring, if available, drive the tube. Do not drive past the bottom of the head piece because compression of the sample will result.

4. Record the length of the tube used to penetrate the material being sampled and the number of blows required to obtain this depth.

5. Withdraw the split spoon and open by unscrewing the bit and head. If a split sample is desired, a clean stainless-steel knife should be used to divide the tube contents in half, lengthwise. This sampler is available in 2- and 3.5-inch diameters. The required sample volume may dictate the use of the larger barrel. If needed, stainless-steel or Teflon sleeves can be used inside the split-spoon. If sleeves removed from the split-spoon are capped immediately, volatilization of contaminants can be reduced. When split-spoon sampling is performed to gain geologic information, all work should be performed in accordance with ASTM D 1586-67 (reapproved in 1974).

6. Cap the sample container, place in a double plastic bag, and attach the label and custody seal. Record all pertinent data in the field logbook and complete the sample analysis request form and chain-of-custody record before collecting the next sample.

7. If required, preserve or place the sample on ice.

8. Follow proper decontamination procedures and deliver samples to the laboratory for analysis.

8.3.6 Test Pit/Trench Excavation

These relatively large excavations are used to remove sections of soils when detailed examination of soil characteristics (horizontal, structure, color, etc.) is required. It is the least cost-effective sampling method because of the relatively high cost of backhoe operation.

1. Prior to any excavations with a backhoe, it is important to ensure that all sampling locations are clear of utility lines and poles (subsurface as well as above surface).

2. Using the backhoe, a trench is dug to approximately 3 feet in width and approximately 1 foot below the cleared sampling depth. Place removed or excavated soils on canvas or plastic sheets, if necessary. Trenches greater than 4 feet deep must be sloped or protected by a shoring system, as required by Occupational Safety and Health Administration (OSHA) regulations.

3. A shovel is used to remove a 1- to 2-inch layer of soil from the vertical face of the pit where sampling is to be done.

4. Samples are collected using a trowel, scoop, or coring device at the desired intervals. Be sure to scrape the vertical face at the point of sampling to remove any soil that may have fallen from above, and to expose soil for sampling. Samples are removed and placed in an appropriate container.

5. If required, ensure that a Teflon liner is present in the cap. Secure the cap tightly onto the sample container. Samples are handled in accordance with E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).

6. Carefully and clearly label the container with the appropriate sample tag, addressing all the categories or parameters listed in E & E's SOP for Sample Packaging and Shipping (see ENV 3.16).

7. Use the chain-of-custody form to document the types and numbers of soil samples collected and logged.

8. Record the time and date of sample collection as well as a description of the sample and any associated air monitoring measurements in the field logbook.

9. Abandon the hole according to applicable state regulations. Generally, excavated holes can simply be backfilled with the removed soil material.

10. Decontaminate sampling equipment, including the backhoe bucket, per E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15).

8.4 Sample Preparation

In addition to sampling equipment, representative sample collection includes sample quantity, volume, preservation, and holding time (see Table 8-2). *Sample preparation* refers to all aspects of sample handling after collection. How a sample is prepared can affect its representativeness. For example, homogenizing can result in a loss of volatiles and is therefore inappropriate when volatile contaminants are the concern.

8.4.1 Sample Quantity and Volume

The volume and number of samples necessary for site characterization will vary according to the budget, project schedule, and sampling approach.

8.4.2 Sample Preservation and Holding Time

Sample preservation and holding times are as discussed in Section 4.

8.4.3 Removing Extraneous Material

Discard materials in a sample that are not relevant for site or sample characterization (e.g., glass, rocks, and leaves), because their presence may introduce an error in analytical procedures.

8.4.4 Homogenizing Samples

Homogenizing is the mixing of a sample to provide a uniform distribution of the contaminants. Proper homogenization ensures that the containerized samples are representative of the total soil sample collected. All samples to be composited or split should be homogenized after all aliquots have been combined. Do not homogenize samples for volatile compound analysis.

TITLE: SOIL SAMPLING
CATEGORY: ENV 3.13
REVISED: August 1997

Table 8-2 Standard Sampling Holding Times, Preservation Methods, and Volume Requirements

Protocol Parameter	Holding Time Soil	Holding Time Water	Minimum Volume Required Soil	Minimum Volume Required Water	Container Type Soil	Container Type Water	Preservation Soil	Preservation Water
SW-846								
VOA[e]	14 days from date sampled	14 days from date sampled	15 g	One 40-mL vial; no air space	Two 40-mL vials; no air space	Two 40-mL vials; no air space	Cool to 4°C (ice in cooler)	Add HCl until pH <2 and cool to 4° (ice in cooler)
Semi-VOA (BNAs)[e]	14 days to extract from date sampled	7 days to extract from date sampled	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
PCBs[d,e]	14 days to extract from date sampled	7 days to extract from date sampled	30 g	1 L	4-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Pesticides/PCBs[d,e]	14 days to extract from date sampled	7 days to extract from date sampled	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Metals[c]	6 months from date sampled	6 months from date sampled	10 g	300 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add HNO_3 until pH <2 and cool to 4°C (ice in cooler)
Cyanide[c]	14 days from date sampled	14 days from date sampled	10 g	100 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add NaOH until pH >12 and cool to 4°C (ice in cooler)
Hexavalent chromium[a]	24 hours from time sampled	24 hours from time sampled	10 g	50 mL	8-oz. glass jar with Teflon-lined cap	125-mL polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Total Organic Carbon (TOC)[a]	NA	28 days from date sampled	5 g	10 mL	8-oz. glass jar with Teflon-lined cap	125-mL polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add H_2SO_4 until pH <2 and cool to 4°C (ice in cooler)
Total Organic Halides (TOX)	NA	7 days from date sampled	100 g	200 mL	8-oz. glass jar with Teflon-lined cap	1-L amber glass bottle	Cool to 4°C (ice in cooler)	Add H_2SO_4 until pH <2 and cool to 4°C (ice in cooler)

Table 8-2 Standard Sampling Holding Times, Preservation Methods, and Volume Requirements

Protocol Parameter	Holding Time		Minimum Volume Required		Container Type		Preservation	
	Soil	Water	Soil	Water	Soil	Water	Soil	Water
Total Recoverable Petroleum Hydrocarbons[e]	28 days from date sampled	28 days from date sampled	50 g	1 L	8-oz. glass jar with Teflon-lined cap	1-L amber glass bottle	Cool to 4°C (ice in cooler)	Add H_2SO_4 until pH <2 and cool to 4°C (ice in cooler)
EPA-CLP								
VOA[e]	10 days from date received	10 days from date received	15 g	One 40-mL vial; no air space	Two 40-mL vials; no air space	Two 40-mL vials; no air space	Cool to 4°C (ice in cooler)	Add HCl until pH <2 and cool to 4°C (ice in cooler)
Semi-VOA (BNAs)[e]	10 days to extract from date received	5 days to extract from date received	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
PCBs[d,e]	10 days to extract from date received	5 days to extract from date received	30 g	1 L	4-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Pesticides/PCBs[d,e]	10 days to extract from date received	5 days to extract from date received	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Metals[c]	6 months from date sampled	6 months from date sampled	10 g	300 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add HNO_3 to pH <2 and cool to 4°C (ice in cooler)
Cyanide[c]	12 days from date received	12 days from date received	10 g	100 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add NaOH to pH >12 and cool to 4°C (ice in cooler)
NYSDEC-CLP								
VOA[e]	7 days from date received	10 days from date received	15 g	One 40-mL vial; no air space	Two 40-mL vials; no air space	Two 40-mL vials; no air space	Cool to 4°C (ice in cooler)	Add HCl until pH <2 and cool to 4°C (ice in cooler)
Semi-VOA (BNAs)[e]	5 days to extract from date received	5 days to extract from date received	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)

Table 8-2 Standard Sampling Holding Times, Preservation Methods, and Volume Requirements

Protocol Parameter	Holding Time		Minimum Volume Required		Container Type		Preservation	
	Soil	Water	Soil	Water	Soil	Water	Soil	Water
PCBs[d,e]	5 days to extract from date received	5 days to extract from date received	30 g	1 L	4-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Pesticides/PCBs[d,e]	5 days to extract from date received	5 days to extract from date received	30 g	1 L	8-oz. glass jar with Teflon-lined cap	½-gallon amber glass bottle	Cool to 4°C (ice in cooler)	Cool to 4°C (ice in cooler)
Metals[c]	6 months from date sampled	6 months from date sampled	10 g	300 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add HNO_3 to pH <2 and cool to 4°C (ice in cooler)
Cyanide[c]	12 days from date received	12 days from date received	10 g	100 mL	8-oz. glass jar with Teflon-lined cap	1-L polyethylene bottle with polyethylene-lined cap	Cool to 4°C (ice in cooler)	Add NaOH to pH >12 and cool to 4°C (ice in cooler)
EPA Water and Waste								
Total Dissolved Solids (TDS)	NA	7 days from date sampled	NA	200 mL	NA	1-L polyethylene bottle with polyethylene-lined cap	NA	Cool to 4°C (ice in cooler)

Note: All sample bottles will be prepared in accordance with EPA bottle-washing procedures. These procedures are incorporated in E & E's Laboratory and Field Personnel Chain-of-Custody Documentation and Quality Assurance/Quality Control Procedures Manual, July 1987.

[a] Technical requirements for sample holding times have been established for water matrices only. However, they are also suggested for use as guidelines in evaluating soil data.
[b] Holding time for GC/MS analysis is 7 days if samples are not preserved.
[c] Maximum holding time for mercury is 28 days from time sampled.
[d] If one container has already been collected for PCB analysis, then only one additional container need be collected for extractable organic, BNA, or pesticides/PCB analysis.
[e] Extra containers required for MS/MSD.

Key:

NA = Not applicable.

8.4.5 Compositing Samples

Compositing is the process of physically combining and homogenizing several individual soil aliquots of the same volume or weight. Compositing samples provides an average concentration of contaminants over a certain number of sampling points. Compositing dilutes high-concentration aliquots; therefore, detection limits should be reduced accordingly. If the composite area is heterogeneous in concentration and its composite value is to be compared to a particular action level, then that action level must be divided by the total number of aliquots making up the composite for accurate determination of the detection limit.

8.4.6 Splitting Samples

Splitting samples (after preparation) is performed when multiple portions of the same samples are required to be analyzed separately. Fill the sample containers simultaneously with alternate spoonfuls of the homogenized sample (see Figure 8-7).

8.5 Post-Operations

8.5.1 Field

Decontaminate all equipment according to E & E's SOP for Sampling Equipment Decontamination (see ENV 3.15).

8.5.2 Office

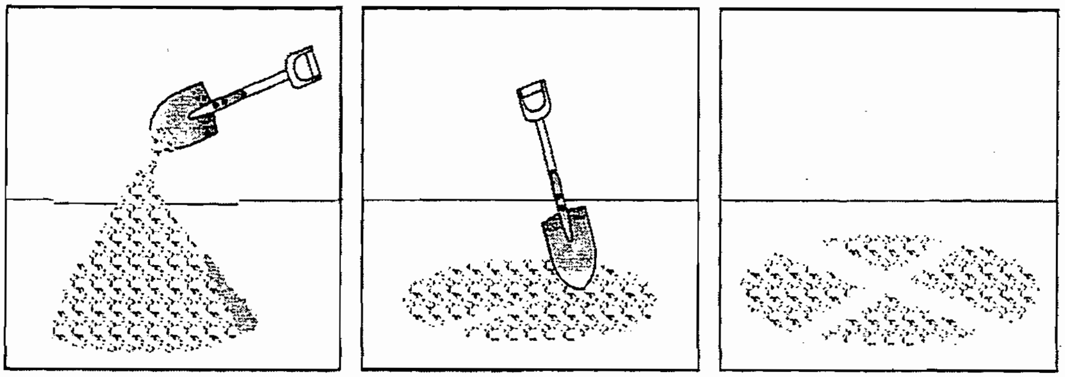
Organize field notes into a report format and transfer logging information to appropriate forms.

9. Calculations

There are no specific calculations required for these procedures.

10. Quality Assurance/Quality Control

The objective of QA/QC is to identify and implement methodologies that limit the introduction of error into sampling and analytical procedures.



Step 1:

- Cone Sample on hard, clean surface
- Mix by forming new cone

Step 2:

- Quarter after flattening cone

Step 3:

- Divide sample into quarters

Step 4:

- Remix opposite quarters
- Reform cone
- Repeat a minimum of 5 times

After: ASTM Standard C702-87

Figure 8-7 Quartering to Homogenized and Split Samples

10.1 Sampling Documentation

10.1.1 Soil Sample Label

All soil samples shall be documented in accordance with E & E's SOP for Sample Packaging and Shipping (see ENV 3.16). The soil sample label is filled out prior to collecting the sample and should contain the following:

1. Site name or identification.
2. Sample location and identifier.
3. Date samples were collected in a day, month, year format (e.g., 03 Jan 88 for January 3, 1988).
4. Time of sample collection, using 24-hour clock in the hours:minutes format.
5. Sample depth interval. Units used for depths should be in feet and tenths of feet.
6. Preservatives used, if any.
7. Analysis required.

8. Sampling personnel.

9. Comments and other relevant observations (e.g., color, odor, sample technique).

10.1.2 Logbook

A bound field notebook will be maintained by field personnel to record daily activities, including sample collection and tracking information. A separate entry will be made for each sample collected. These entries should include information from the sample label and a complete physical description of the soil sample, including texture, color (including notation of soil mottling), consistency, moisture content, cementation, and structure.

10.1.3 Chain of Custody

Use the chain-of-custody form to document the types and numbers of soil samples collected and logged. Refer to E & E's SOP for Sample Packaging and Shipping (see ENV 3.16) for directions on filling out this form.

10.2 Sampling Design

1. Sampling situations vary widely; thus, no universal sampling procedure can be recommended. However, a Sampling Plan should be implemented before any sampling operation is attempted, with attention paid to contaminant type and potential concentration variations.

2. Any of the sampling methods described here should allow a representative soil sample to be obtained, if the Sampling Plan is properly designed.

3. Consideration must also be given to the collection of a sample representative of all horizons present in the soil. Selection of the proper sampler will facilitate this procedure.

4. A stringent QA Project Plan should be outlined before any sampling operation is attempted. This should include, but not be limited to, properly cleaned samplers and sample containers, appropriate sample collection procedures, chain-of-custody procedures, and QA/QC samples.

11. Data Validation

The data generated will be reviewed according to the QA/QC considerations that are identified in Section 10.

00104

11.1 Quality Assurance/Quality Control Samples

QA/QC samples are used to identify error due to sampling and/or analytical methodologies and chain-of-custody procedures.

11.1.1 Field Duplicates (Replicates)

Field duplicates are collected from one location and treated as separate samples throughout the sample handling and analytical processes. These samples are used to assess total error for critical samples with contaminant concentrations near the action level.

11.1.2 Collocated Samples

Collocated samples are generally collected 1.5 to 3.0 feet away from selected field samples to determine both local soil and contaminant variations on site. These samples are used to evaluate site variation within the immediate vicinity of sample collection.

11.1.3 Background Samples

Background or "clean" samples are collected from an area upgradient from the contamination area and representative of the typical conditions. These samples provide a standard for comparison of on-site contaminant concentration levels.

11.1.4 Rinsate (Equipment) Blanks

Rinsate blanks are collected by pouring analyte-free water (i.e., laboratory de-ionized water) on decontaminated sampling equipment to test for residual contamination. These samples are used to assess potential cross contamination due to improper decontamination procedures.

11.1.5 Performance Evaluation Samples

Performance evaluation samples are generally prepared by a third party, using a quantity of analyte(s) known to the preparer but unknown to the laboratory. The percentage of analyte(s) identified in the sample is used to evaluate laboratory procedural error.

11.1.6 Matrix Spike/Matrix Spike Duplicates (MS/MSDs)

MS/MSD samples are spiked in the laboratory with a known quantity of analyte(s) to confirm percent recoveries. They are primarily used to check sample matrix interferences.

11.1.7 Field Blanks

Field blanks are prepared in the field with certified clean sand, soil, or water. These samples are used to evaluate contamination error associated with sampling methodology and laboratory procedures.

00105

11.1.8 Trip Blanks

Trip blanks are prepared prior to going into the field using certified clean sand, soil, or water. These samples are used to assess error associated with sampling methodology and analytical procedures for volatile organics.

12. Health and Safety

12.1 Hazards Associated with On-Site Contaminants

Depending on site-specific contaminants, various protective programs must be implemented prior to soil sampling. The site Health and Safety Plan should be reviewed with specific emphasis placed on a protection program planned for direct-contact tasks. Standard safe operating practices should be followed, including minimization of contact with potential contaminants in both the vapor phase and solid matrix by using both respirators and disposable clothing.

Use appropriate safe work practices for the type of contaminant expected (or determined from previous sampling efforts):

- Particulate or Metals Contaminants
  - Avoid skin contact with, and ingestion of, soils and dusts.
  - Use protective gloves.

- Volatile Organic Contaminants
  - Pre-survey the site with an HNu 101 or OVA 128 prior to collecting soil samples.
  - If monitoring results indicate organic constituents, sampling activities may be conducted in Level C protection. At a minimum, skin protection will be afforded by disposable protective clothing.

13. References

ASTM D 1586-67 (reapproved 1974), ASTM Committee on Standards, Philadelphia, PA.

ASTM D 1586-84, Penetration Test and Split Barrel Sampling of Soils.

Barth, D. S. and B. J. Mason, 1984, *Soil Sampling Quality Assurance User's Guide*, EPA-600/4-84-043.

de Vera, E. R., B. P. Simmons, R. D. Stephen, and D. L. Storm, 1980, *Samplers and Sampling Procedures for Hazardous Waste Streams*, EPA-600/2-80-018.

Ecology and Environment, Inc., 1990, *Standard Operating Procedures*: "Equipment Decontamination," and "Sample Packaging and Shipping."

Mason, B. J., 1983, *Preparation of Soil Sampling Protocol: Technique and Strategies*, EPA-600/4-83-020.

U.S. Environmental Protection Agency (EPA), 1984, *Characterization of Hazardous Waste Sites – A Methods Manual: Volume II, Available Sampling Methods*, (2nd ed.), 1984, EPA-600/4-84-076.

__________, 1991, *Removal Program Representative Sampling Guidance: Volume I – Soil*, (Interim Final), EPA-9360.4-10.

__________, 1984, *Characterization of Hazardous Waste Sites – A Methods Manual: Volume I, Site Investigations*, Section 7: Environmental Monitoring Systems Laboratory, Las Vegas, Nevada, EPA/600/4-84/075.

__________, February 1989, *Methods for Evaluating the Attainment of Cleanup Standards: Volume I, Soils and Solid Media*, EPA/230/02-89/042.

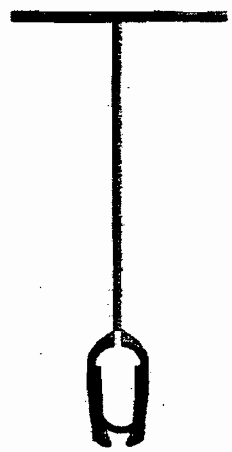
A SAMPLING AUGERS

A. Sampling Augers

(a)
Ship Auger

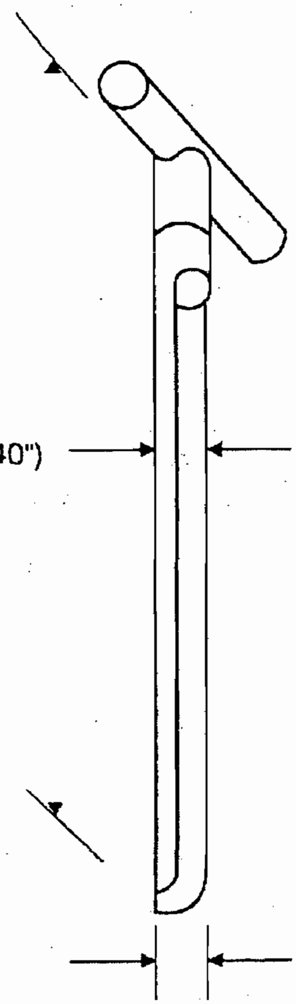
(b)
Closed-Spiral Auger

(c)
Open-Spiral Auger

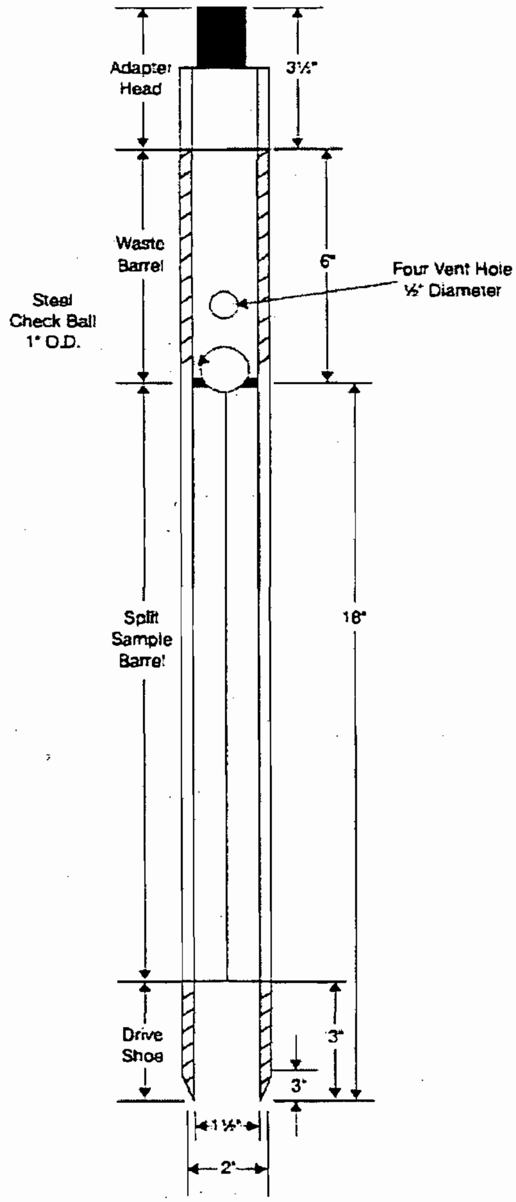


(d)
Iwan Auger

B SAMPLING TRIER



C SPLIT-SPOON SAMPLER



00110

Title:	BOREHOLE SAMPLING
Category:	ENV 3.3
Revised:	April 1998

STANDARD OPERATING PROCEDURE

BOREHOLE SAMPLING

ecology and environment, inc.
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TITLE:	BOREHOLE SAMPLING		
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1. Introduction

1.1 Scope

This document presents an in-depth discussion of the techniques used to obtain subsurface soil samples from boreholes.

1.2 Objectives

Most subsurface investigations require the drilling of boreholes for one or more purposes, including: collection of soil samples for lithologic logging and laboratory testing; lithologic and hydrogeologic characterization using borehole geophysical logging; and installation of piezometers or monitoring wells. Drilling methods are selected based on availability and cost; suitability for the type of geologic materials at a site (unconsolidated or consolidated); and possible effects on sample integrity (potential influence of drilling fluids and for cross contamination between aquifers).

A wide variety of drilling methods have been developed that may be suitable for one or more of the purposes described above. Table 1 summarizes information on 21 drilling methods. The hollow-stem auger (HSA) is the most commonly used method for well installation in unconsolidated deposits. Air rotary drilling is probably the most commonly used method for well installation in consolidated formations. Table 2 provides information on the relative performance of 11 of the drilling methods listed in Table 1 for different types of geologic formations. Subsurface soil samples are collected from boreholes for chemical and physical analysis, and to aid in the definition and tracking of contaminants in the soil. The type subsurface soil sample may be either undisturbed or disturbed. and either composite or discrete. The type of sample to be collected depends on the purpose of the investigation and the drilling technique.

2. Drilling and Sampling Techniques

The most accurate method for obtaining information on the characteristics of unconsolidated deposits is to collect representative samples of soil at measured depths and at intervals that will provide a complete stratigraphic and lithologic profiles of soils and bedrock, respectively. For most boreholes, subsurface soil samples are collected continuously, at 2- or 5-foot intervals, or at every change in the formation.

Table 1 Summary Information on Drilling Methods

Drill Method	Casing/Open Hole	Fluids Affect Chem.?	Core Samples?
Open-Hole Rotary Methods			
Hollow-Stem Auger	Open hole	Usually no fluids	Possible
Direct Air Rotary with Bit	Open hole	Yes	Possible
Direct Air Rotary with Downhole hammer	Open hole	Yes	Possible
Direct Mud Rotary	Open hole	Yes	Possible
Reverse Rotary (no casing)	Open hole	Yes	Possible
Cable Tool	Either	Usually no	Possible
Rotary Drill-Through Methods			
Rotary Casing Driver	Casing	Yes	Possible
Dual Rotary Advancement	Casing	Yes	Possible
Reverse Circulation Methods			
Reverse Duel Wall Rotary	Casing	Yes	Possible
Reverse Duel Wall Percussion	Casing	Yes	Possible
Hydraulic Percussion	Casing	Yes	Possible
Downhole Casing Advancers	Casing	Yes	Possible
Jet Percussion	Casing	Possible	Possible
Jetting	Open hole	Possible	No
Solid-Stem Auger	Open hole	No	Possible
Bucket Auger	Open hole	No	Possible
Rotary Diamond	Open hole	Possible	Yes
Directional Drilling	Either[a]	Possible	Possible[a]
Sonic Drilling	Either	Possible	Yes
Driven Wells	Either	No	No
Cone Penetration	Open hole	No	Possible[b]

[a] Sampling with a device resembling a split spoon may be possible with some directional rigs.
[b] Geoprobe has developed a core sampler for use with a cone penetrometer type (CPT) rig.

Key:

Shading indicates most commonly used methods for monitoring well installation.

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Table 2 Relative Performance of Different Drilling Methods in Various Types of Geologic Formations

Type of Formation	Cable Tool	Direct Rotary (with fluids)	Direct Rotary (with air)	Direct Rotary (Down-the-hole-air Hammer)	Direct Rotary (Drill-through casing hammer)	Reverse Rotary (with fluids)	Reverse Rotary (Dual Wall)	Hydraulic Percussion	Jetting	Driven	Auger
Dune sand	2	5	NR	NR	6	5[a]	6	5	5	3	1
Loose sand and gravel	2	3-5	NR	NR	6	5[a]	6	5	5	3	1
Quicksand	2	5	NR	NR	6	5[a]	6	5	5	NR	1
Loose boulders in alluvial fans or glacial drift	3-2	2-1	NR	NR	5	2-1	4	1	1	NR	1
Clay and silt	3	5	NR	NR	5	5	5	3	3	NR	3
Firm shale	5	5	NR	NR	5	5	5	3	NR	NR	2
Sticky shale	3	5	NR	NR	5	3	5	3	NR	NR	2
Brittle shale	5	5	NR	NR	5	5	5	3	NR	NR	NA
Sandstone—poorly cemented	3	4	NR	NR	NA	4	5	4	NR	NR	NA
Sandstone—well cemented	3	3	5	NR	NA	3	5	3	NR	NR	NA
Chert nodules	5	3	3	NR	NA	3	3	5	NR	NR	NA
Limestone	5	5	5	6	NA	5	5	5	NR	NR	NA
Limestone with chert nodules	5	3	5	6	NA	3	3	5	NR	NR	NA
Limestone with small cracks or fractures	5	3	5	6	NA	2	5	5	NR	NR	NA
Limestone, cavernous	5	3-1	2	5	NA	1	5	1	NR	NR	NA
Dolomite	5	5	5	6	NA	5	5	5	NR	NR	NA
Basalts, thin layers in sedimentary rocks	5	3	5	6	NA	3	5	5	NR	NR	NA
Basalts—thick layers	3	3	4	5	NA	3	4	3	NR	NR	NA
Basalts—highly fractured (lost circulation zones)	3	1	3	3	NA	1	4	1	NR	NR	NA

Table 2 Relative Performance of Different Drilling Methods in Various Types of Geologic Formations

Type of Formation	Cable Tool	Direct Rotary (with fluids)	Direct Rotary (with air)	Direct Rotary (Down-the-hole-air hammer)	Direct Rotary (Drill-through casing hammer)	Reverse Rotary (with fluids)	Reverse Rotary (Dual Wall)	Hydraulic Percussion	Jetting	Driven	Auger
Metamorphic rocks	3	3	4	5	NA	3	4	3	NR	NR	NA
Granite	3	3	5	5	NA	3	4	3	NR	NR	NA

[a] Assuming sufficient hydrostatic pressure is available to contain active sand (under high confining pressures).

Rate of Penetration:

1 = Impossible
2 = Difficult
3 = Slow
4 = Medium
5 = Rapid
6 = Very rapid

Key:

NA= Not applicable.
NR= Not recommended.

Source: Driscoll (1986).

2.1 Disturbed and Undisturbed Samples

Soil samples from unconsolidated deposits can be collected as disturbed or undisturbed soil samples. Disturbed soil samples are produced by HSA drilling and are therefore referred to as drill cuttings. The components of a HSA are shown in Figure 1. Disturbed samples are not representative of the formations penetrated because of the possible sorting and grinding of the cuttings while being carried to the surface. In general, disturbed samples do not contain detailed lithologic information, and the depth at which the soil is encountered is not precisely known. Undisturbed soil samples are collected by a variety of sampling devices, including the split-barrel sampler (see Figure 2), the Laskey sampler (see Figure 3), and the Shelby tube sampler. The collection of undisturbed samples helps to ensure the preservation of detailed lithologic information such as the degree of consolidation, sorting, bedding, etc., and provides a more accurate determination of sample depth.

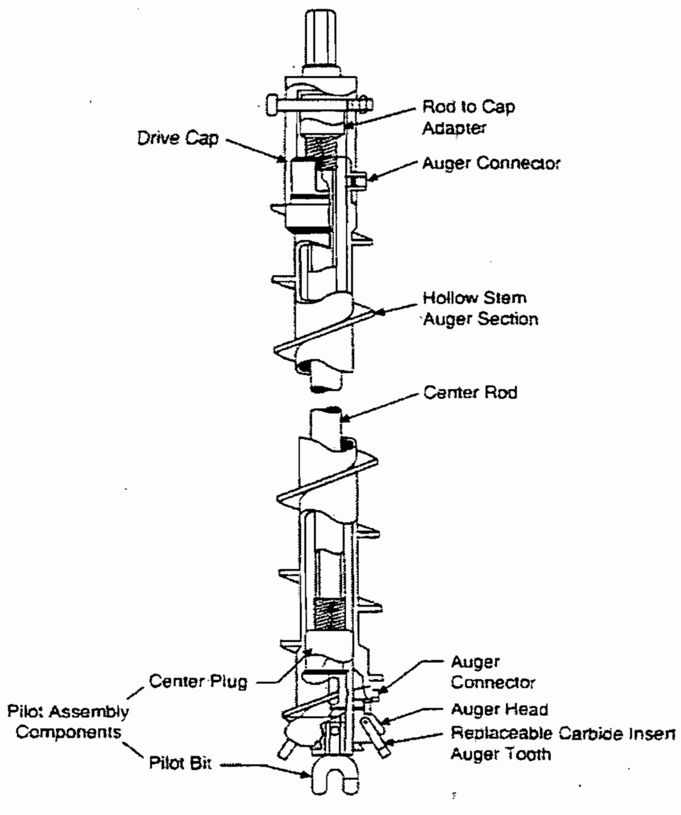

Figure 1 Typical Components of a Hollow-Stem Auger

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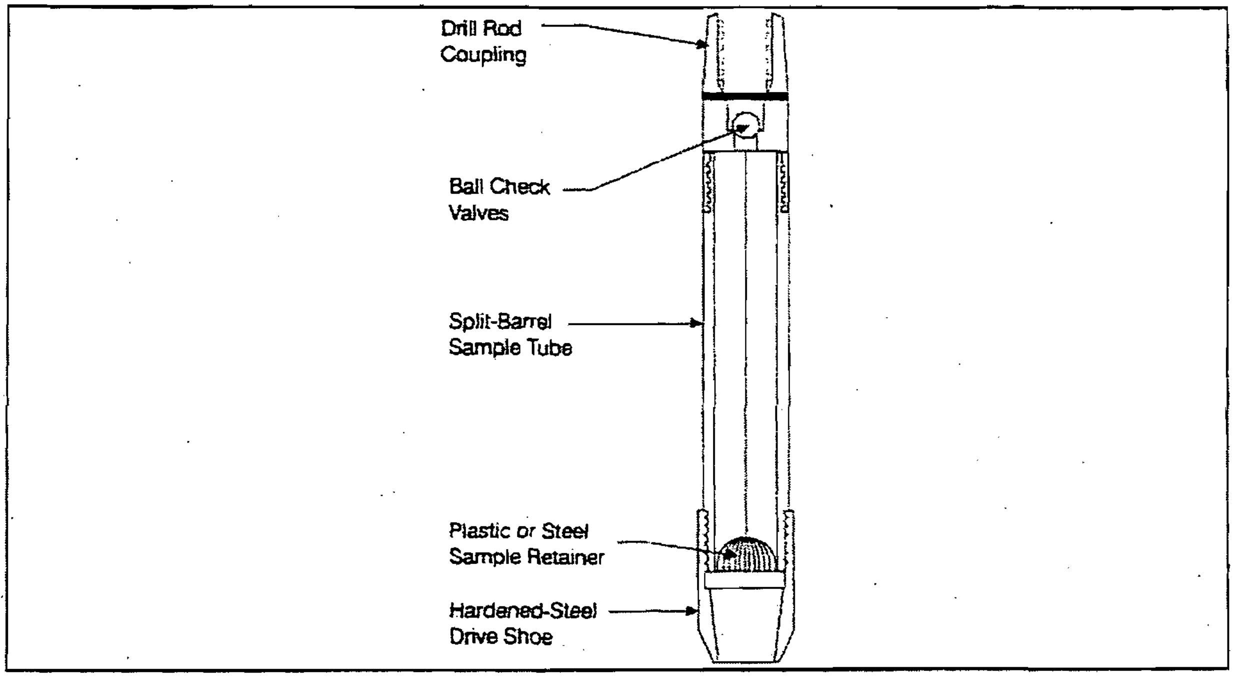

Figure 2 Split-Spoon or Split-Barrel Sampler

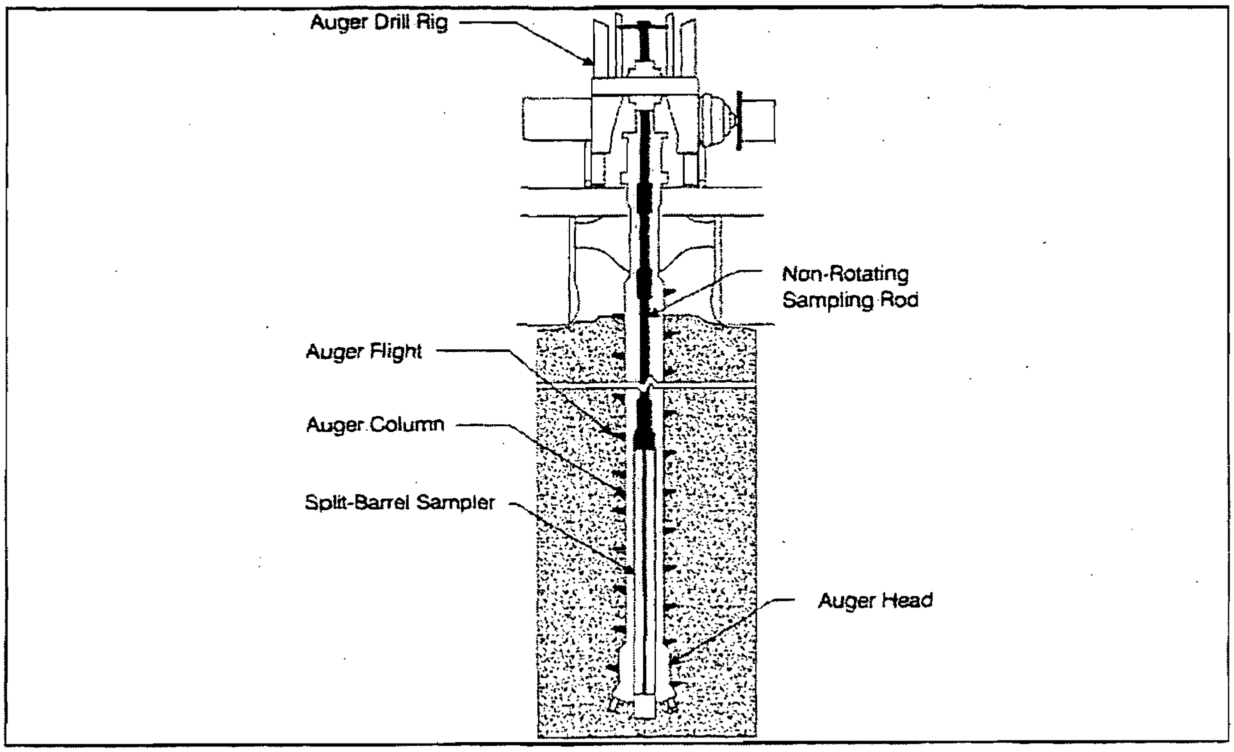

Figure 3 Continuous Sampling Tube System

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2.2 Discrete and Composite Samples

Discrete samples are obtained from a specific depth and are used when detailed analytical information about overburden soils is required. Analysis of discrete unconsolidated soil samples provides more accurate information on the depth of contamination.

Composite samples are prepared from aliquots of discrete samples. They are used for obtaining a representative sample from a subsurface interval for analytical purposes. Composite samples are not appropriate for use in stratigraphic description.

3. Borehole Drilling

3.1 Inspection and Cleaning of Sampling Equipment

Proper cleaning, including steam-cleaning, of the drill rig, down-hole equipment, and sampling equipment, should be performed upon arriving at the site and between drilling locations. This is necessary to minimize the potential introduction of contaminants into unconsolidated soil samples. The drill rig should also be checked repeatedly for oil and hydraulic fluid leaks. These precautions are essential to ensure that contaminants from the drilling process are not introduced into the samples. If specified in the site-specific work plan (SSWP), all non-disposable sampling equipment may need to be decontaminated according to specific procedure referenced in the SSWP.

3.2 Hollow-Stem Auger Drilling

A HSA column simultaneously rotates and axially advances by a mechanically or hydraulically powered drill rig. The hollow stem of the auger allows the use of various methods for continuous or intermittent sampling of subsurface soils. HSA columns are manufactured in 5-foot lengths and have inside diameters (IDs) ranging from 2.25-inch ID to 10.25-inch ID. Drilling with augers of different diameters makes possible the use of casings to isolate near-surface contamination while drilling continues with a smaller-diameter auger. In addition, the riser and screen for monitoring wells can be placed in the HSAs when the desired depth of drilling has been reached, and filter pack and grouting can be emplaced as the HSAs are gradually withdrawn from the hole.

If a split-barrel soil sampler is used to collect samples from unconsolidated deposits, a center plug with the same diameter as the HSAs, and a section of drilling rod are placed inside the lead flight. The HSAs are advanced through the unconsolidated deposit to the first sampling interval, and the center plug is then removed from the HSA. A precleaned split-barrel soil sampler is attached to the end of the drilling rod and lowered into the HSAs. A safety hammer is attached to the top of the drilling rod and the split-barrel soil sampler is driven into the undisturbed soil in an increment of 2 feet. The split-barrel soil sampler is then raised and opened to remove the soil sample. The center plug is then re-placed into the HSAs, and another HSA flight is attached to the top of the flight already in the ground. The process is repeated until bedrock is encountered or the project depth is reached.

A Laskey soil sampler is used to collect a continuous 5-foot soil sample while the HSAs are turning. The Laskey soil sampler is used instead of a center plug in 4.25-inch HSAs, and the head of the sampler is advanced ahead of the HSAs by 2 to 6 inches. Upon completion of a 5-foot run of HSAs, the Laskey soil sampler is recovered and opened in a manner similar to a split-barrel sampler. Following sample collection and decontamination of the Laskey soil sampler, the sampler is re-placed into the HSAs, and another flight of HSAs is attached to the top of the flight already in the ground.

A Shelby tube sampler is used to collect samples of undisturbed overburden usually for collection of geotechnical samples. Shelby tubes are available in a variety of diameters and lengths. The most common Shelby tubes are 3 to 5 inches I.D. and 18 to 30 inches long. Once the HSAs have reached the top of the interval to be sampled, the drilling rods holding the center plug are withdrawn from the HSAs. The Shelby tube is then attached to the end of the drilling rod and lowered into the HSAs. The Shelby tube is "pushed" out the bottom of the HSAs to the prescribed depth and then retrieved. The tube is not opened in the field; the ends are sealed (with wax) and it is shipped to the laboratory intact. The process is repeated until bedrock is encountered or the project depth is reached.

3.3 Direct Air Rotary, Mud Rotary, and Downhole Hammer Drilling

The basic rig setups for air or mud rotary with tri-cone or roller-cone bit are similar, except for the circulation medium used. Compressed air or mud is circulated down through the drill rods to cool the bit and carry cuttings up the hole to the surface. For air rotary drilling, a cyclone separator is used to slow the air velocity and allow the cuttings to fall into a container. A down-the-hole hammer, which operates with a percussive (pounding) action as it rotates, is used for air rotary drilling. For mud rotary drilling, a tri-cone roller bit is used.

3.4 Cable Tool Drilling

Cable tool drilling rigs operate by repeatedly lifting and dropping a heavy string of drilling tools attached to a cable into the borehole. Consolidated rock is broken or crushed into small fragments, and unconsolidated material is loosened by the drill bit. The reciprocating action is caused by attaching the cable to an eccentric walking or spudding beam that also serves to mix the crushed or loosened particles with water to form a slurry at the bottom of the borehole. Periodically, the drilling string is removed and the slurry is removed by a sand pump or bailer. In unconsolidated formations, a casing is driven into the ground to keep the hole open.

A sample of cable tool cuttings should include more than one bailer load of material to provide a composite sample that is reasonably representative of the sampling interval. This is particularly important when sampling sand and gravel formations. The cable tool drilling method is not as common a method for installing monitoring wells as it once was.

3.5 Other Methods for Collecting Shallow Subsurface Soil Samples

Several methods are available for obtaining shallow subsurface soil samples (less than 10 feet) without using a drill rig.

- Hand Augers. These are useful for obtaining samples from shallow depths in unconsolidated formations. Samples are collected from a bucket auger advanced by hand through shallow depth intervals.
- Power Augers. These are usually hand augers powered by a gasoline engine. Disturbed soil samples are collected from the auger flight as the tool is turned.
- Backhoes. Backhoes are relatively inexpensive and can excavate a slit trench up to 12 feet deep very quickly. Samples can be obtained by attaching a Shelby tube to the bucket or by collecting samples directly out of the bucket.
- Geoprobe. This is a truck- or van-mounted hydraulic unit which pushes or hammers a small diameter probe into shallow, unconsolidated soils. The unit can be used to collect samples of subsurface soils, soil gas, or groundwater.

4. Borehole Abandonment

Borehole abandonment is necessary to eliminate potential physical hazards, to prevent groundwater contamination, to conserve aquifer yield and hydrostatic head, and to prevent intermixing of subsurface water. After the necessary unconsolidated soil samples or consolidated core samples have been collected from the borehole, the HSAs are removed from the borehole and the HSA flights are cleaned and appropriately decontaminated. A cement/bentonite grout should be tremied into the borehole to the surface. The grout should consist of potable water, bentonite powder, and Type I portland cement, with 94 pounds of cement and 5 pounds of bentonite per 6.5 gallons of water. In certain areas, specific borehole or well abandonment methods are specified in the associated environment regulations and these methods must be adhered to.

5. Disposal of Drill Cuttings and Decon Liquids

5.1 Containerization of Drill Cuttings and Decon Liquids

Drill cuttings must be handled as outlined in the work plan for the site. In some instances, the drill cuttings are classified as hazardous waste under the Resource Conservation and

Recovery Act (RCRA) and must be placed in U.S. Department of Transportation (DOT)-approved 55-gallon steel drums pending analysis. The drums of drill cuttings must be properly labeled and marked with the contents, date, and source of the drill cuttings (e.g., "MW-2") prior to being staged.

Decon fluids may also be placed in DOT-approved 55-gallon steel drums pending analysis. The drums of decon liquids must be properly labeled and marked with the type and source of the fluids and the date the drum was filled prior to being staged.

In instances when field monitoring for the presence of contaminants in soil and water is performed, approval for not containerizing investigation-derived soil and water may be approved by the local regulatory agency. This approval must be obtained prior to the commencement of the field investigation.

5.2 Disposal of Drill Cuttings and Decon Liquids

Upon receipt of the analytical results, the drill cuttings and decon liquids can be properly classified. It is the responsibility of the property owner and/or client to arrange for the disposal of the drill cuttings and fluids at an approved facility.

6. Bibliography

Acker, W.L. 1974, Basic Procedures for Soil Sampling and Core Drilling. Acker Drill Co., Scranton, PA.

American Petroleum Institute (API), 1973, Procedures for Selecting Rotary Drilling Equipment, 2nd edition. API Bulletin D10. API, Washington, DC.

American Society for Testing and Materials (ASTM), 1980, Standard Practice for Soil Investigation and Sampling by Auger Borings, D1452-80, (Vol. 4.08), ASTM, Philadelphia, PA.

American Society for Testing and Materials (ASTM), 1993, Draft Standard Guide for the Use of Hollow-Stem Augers for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices, D18.21 Ballot 93-03, ASTM Philadelphia, PA.

Corps of Engineers, 1972, Soil Sampling, EM 1110-2-1907, COE, Department of the Army, Washington, DC.

Driscoll, F.G., 1986, *Groundwater and Wells,* 2nd ed.

Hackett, G. 1987, Drilling and Constructing Monitoring Wells with Hollow Stem Augers: Part 1, Ground Water Monitoring Review 7(4):51-62.

U.S. Army, 1981, Well Drilling Operations, Department of Army Technical Manual FM5-11-61/AFR 85-23.

U.S. Army Toxic and Hazardous Material Agency (USATHAMA), 1982, Minimum Requirement for Boring Logs, Drilling Procedures, Monitoring Well Installation, and Associated Data Management System Entries, USATHAMA, Aberdeen Proving Ground, MD.

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STANDARD OPERATING PROCEDURE

GEOPROBE OPERATION

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1. Introduction

1.1 Scope

This document provides basic information on the operation and application of the Geoprobe Model 8-A hydraulic sampler for subsurface investigations. E & E uses the Geoprobe for hazardous waste site investigations. In addition, field procedures and limitations of the Geoprobe are discussed. This document is meant to be used in conjunction with other E & E standard operating procedures for field operations and incorporates all of the safety precautions that should be followed when planning a Geoprobe subsurface investigation.

1.2 Objectives

Geoprobes can collect one-time subsurface samples to determine the presence and/or extent of contaminants in soil gas, groundwater, and soils with a minimum disturbance of the ground surface. The Geoprobe Model 8-A is a hydraulically powered, van-mounted subsurface sampling device capable of collecting subsurface soil gas samples, subsurface soil samples, and groundwater samples. The information obtained from the Geoprobe investigation can be used to define the extent of contamination in the area and assist in determining the placement of monitoring wells.

1.3 Method Selection Considerations

The Geoprobe provides a means of rapidly assessing the presence of contaminants in near-surface unconsolidated soils. The Geoprobe 8-A can penetrate much farther in dry, loose soil than in tightly bound clay and is not recommended for use in rocky soils or tightly compacted glacial till deposits. Other subsurface investigation methods should be considered for sampling in consolidated deposits. Use of the Geoprobe 8-A in these situations may result either in damage to the Geoprobe or injury to the operator.

2. Description

The Geoprobe 8-A is a hydraulically powered probing device. The unit consists of a powered percussion hammer that is slide-mounted on a derrick and has a 3.5-foot stroke. The derrick assembly hydraulically folds and unfolds from the traveling or storage position in the rear compartment of the van. The derrick is also adjustable in both the fore and aft directions, as well as angle, to ensure the derrick is vertical. There are no side-to-side adjustments on E & E's commercial Geoprobes.

The Geoprobe 8-A uses the weight of the van and a hydraulically powered percussion hammer to advance 3-foot-long rods into the ground. The probe rods are hardened steel with an inside diameter (ID) of 0.5 inch and an outside diameter (OD) of 1 inch. The operator controls the hydraulic hammer through the use of levers, and the helper assists by adding sections of rod. Depending on the purpose of the investigation, the lead rod will be equipped to collect soil, groundwater, or soil gas samples. After the lead rod has been driven into the ground 2.5 feet, the helper attaches an additional 3-foot-long section of rod and the process is repeated until the desired depth has been reached.

3. Responsibilities

3.1 Operator

The crew consists of an operator and a helper. The operator is responsible for the safe and efficient operation of the Geoprobe, and also performs the daily inspections and maintenance. In addition, the operator inventories the supplies and equipment daily and ensures that an adequate supply of expendable parts are on hand.

The operator is responsible for completing the subsurface investigation in accordance with the site-specific work plan and in a safe manner consistent with the site health and safety plan. Routinely, the operator is also the field team leader and as such, is responsible for (1) the quality of the samples recovered from the Geoprobe; (2) compliance with the project's quality assurance/quality control requirements; and (3) completion of the site log.

If the operator observes any unsafe or potentially dangerous situations, the operator will stop operations until the proper corrective actions have been taken. The operator has the authority to secure operations at any location if the operator concludes that the conditions are dangerous or could compromise the quality of the samples.

3.2 Helper

The primary function of the helper is to assist the operator in conducting the subsurface investigation. The helper is responsible for assembling, securing, and disassembling the rods and other sampling tools used in the investigation. The helper is also responsible for ensuring that all of the equipment is properly decontaminated and that all tools are in proper working order.

If the helper notices any unsafe or potentially dangerous situations, the helper will inform the operator immediately. The helper must be attentive to conditions around the Geoprobe because the operator will be concentrating on the operation of the unit.

3.3 Site Safety Coordinator

The site safety coordinator (SSC) is responsible for ensuring that the subsurface investigation is completed as outlined in the site health and safety plan. The SSC will ensure that all overhead and buried utilities (e.g., electrical lines, telephone lines, natural gas lines) have been identified and located prior to commencing the subsurface investigation. The SSC will be familiar with the operations of the Geoprobe and the potential hazards posed by its operation. In many cases, the operator or helper also serves as the SSC.

4. Planning the Geoprobe Survey

In planning the Geoprobe survey, research should be conducted on local and regional geology and hydrogeologic conditions; historic records on the size of the site; past waste disposal practices; types of waste material disposed of at the site; and depth and orientation of waste material. Sites should be evaluated in terms of their hydrogeologic setting. This evaluation will indicate the effectiveness of the survey, given site conditions.

4.1 Researching the Site

Prior to designing the field survey, the following information should be collected, if available, from reconnaissance surveys, interviews, and research reviews:

- Information on the types and locations of materials that may be buried on site to determine where subsurface investigations should not be conducted with a Geoprobe, and to identify the type(s) of samples to be collected;

- Information on the surface layout of the site being studied, including information on topography, site boundaries, and the locations of buildings, rail lines, overhead and buried utility lines (e.g., electric lines, pipelines, etc.), scrap disposal areas, and other structures that may prevent the proper operation of the Geoprobe; and

- Maps, drawings, and photographs of the area; historical aerial photographs may indicate previous disposal areas and poor waste disposal practices, and can also provide a base map for plotting data.

4.2 Defining and Mapping the Survey Site

After obtaining background data, the proposed sampling locations should be laid out based on the locations of buried material. Safety and accessibility are other factors to consider when locating sampling locations.

5. Field Procedures

5.1 Overhead and Buried Utilities

The use of a Geoprobe on a site or project near electrical power lines and other utilities requires that special precautions be taken by both the operator and the helper. Electricity can shock, burn, and cause death. By law, overhead and buried utilities must be located, noted, and emphasized on all subsurface investigation location plans and assessment sheets. When overhead electrical power lines exist at or near the site, consider all wires to be live and dangerous. Watch for sagging power lines before entering the site. Do not lift power lines to gain entrance; call the power company and ask them to raise the lines or de-energize the lines. Before raising the derrick near power lines, walk completely around the unit. Determine what the minimum distance from any point on the unit to the nearest power line will be when the derrick is being raised. Do not raise the derrick or operate the unit if this distance is less than 25 feet or, if known, the minimum clearance stipulated by federal, state, and local regulations. To avoid contact with power lines, never move the Geoprobe with the derrick in a raised position.

If there are any questions concerning the safety of drilling on sites near overhead power lines, contact the power company. The power company will provide expert advice at the site as a public service at no cost.

Underground electrical utilities are as dangerous as overhead power lines. Be aware and always suspect the existence of underground utilities. If a sign warning of underground utilities is located on a site boundary, do not assume that underground utilities are located on or near the boundary or property line under the sign. Always contact the owners of utilities and determine jointly the precise location of underground utility lines, and mark or flag the locations. Besides electrical, other utilities that need to be checked are gas, telephone, water, cable TV, fiber optics (very important because of the cost to repair them), and sewer. Potentially responsible parties (PRPs) are often uncooperative in this regard. Private locators can be contracted to survey areas that the utility locators will not.

5.2 Operating the Geoprobe

5.2.1 Visual Inspection

At the start of each work day, the operator must visually inspect the Geoprobe. This includes (1) checking the hydraulic fluid levels and the hydraulic lines for fraying, cuts, or leaks; (2) checking the derrick and attachments assembly for adequate lubrication and for damage, nicks, burrs, and leaks; (3) removing any unnecessary dust, dirt, or oil to prevent jams or damage to the equipment; (4) checking nuts and bolts; and (5) checking the sampling equipment (e.g., drive rods, anvils, and pull caps). Figures 1 and 2 show the inspection points on the Geoprobe 8-A.

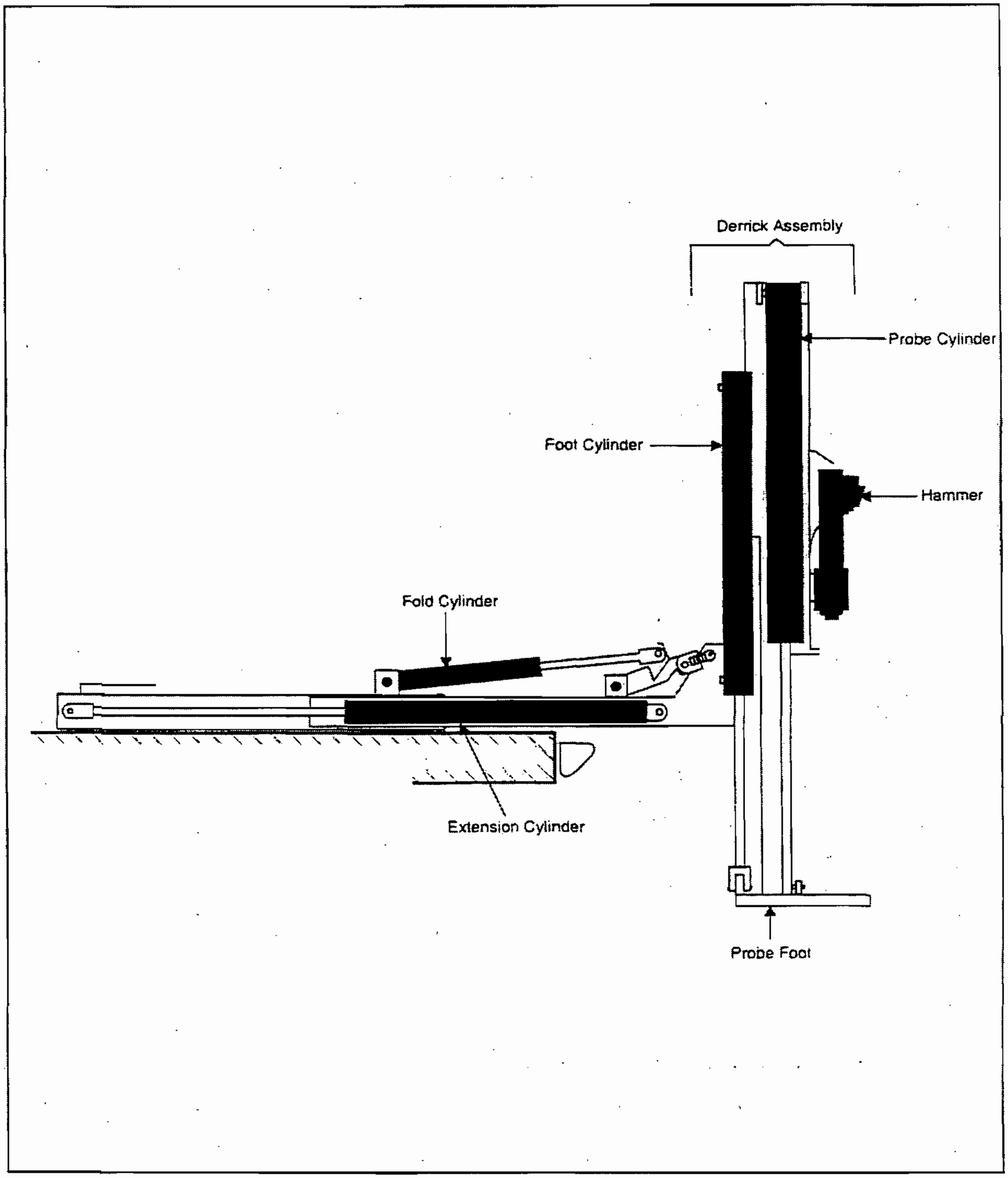

Figure 1 Side View of Inspection Points on the Hydraulic Unit

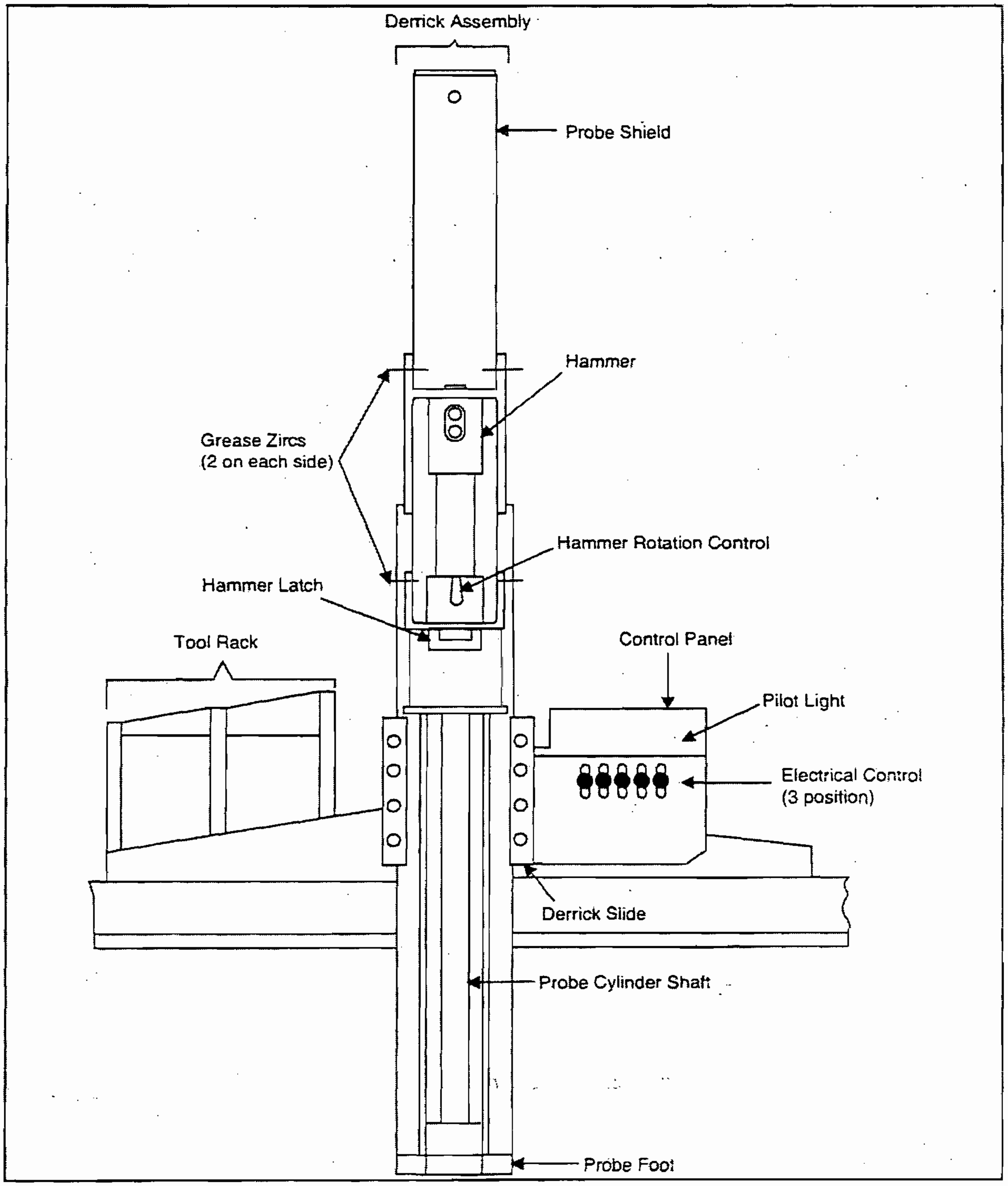

Figure 2 · Front View of Inspection Points on the Hydraulic Unit

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5.2.2 Setup of the Geoprobe

Following the visual inspection and routine maintenance of the Geoprobe, the unit is ready for operation. The following steps describe the setup procedures for the Geoprobe 8-A:

- Position the vehicle at the sampling location. Park the van as level as possible; the van must be level in the side-to-side aspect to drive the rods properly. If on an incline, point the front of the van upgradient. If possible, face the van downwind to avoid potential cross-contamination from the vehicle's exhaust and to prevent exhaust fumes from entering the work area.

- Set the parking brake and position the chock blocks in front of the front wheels.

- Open and secure the rear doors in the open position with the bungee cords provided so that wind or vibrations will not cause the doors to swing into the work area during operation.

- Attach the exhaust hose to the tailpipe and direct the exhaust downwind from the work area.

- Start the vehicle engine with the remote ignition switch located on the side panel inside the rear of the vehicle. Switch the cooling fan to the "on" position (switch in side panel). Set the toggle switch on the Geoprobe 8-A control panel to the middle (slow) position to activate the hydraulic system clutch. See Figure 3 for a diagram of the control panel.

- Push the FOLD lever down to raise the derrick assembly from its resting position to clear the hydraulic hoses. The derrick assembly should be raised no more than 1 foot because of the clearance restrictions of the rear doors.

- Push the EXTEND lever down to move the derrick assembly backward out of the vehicle. Watch the clearance of the derrick at the top of the door opening. Extend the derrick to the full back position so that the top of the derrick will clear the van doors when raising the derrick.

- Push the FOLD lever down again to raise the derrick to a vertical position.

- Lift the EXTEND lever to bring the derrick assembly back close to the vehicle to lessen the strain on the derrick mount assembly. Proper position is approximately 1 foot behind the rear bumper.

- Push down on the FOOT lever until the foot contacts the ground.

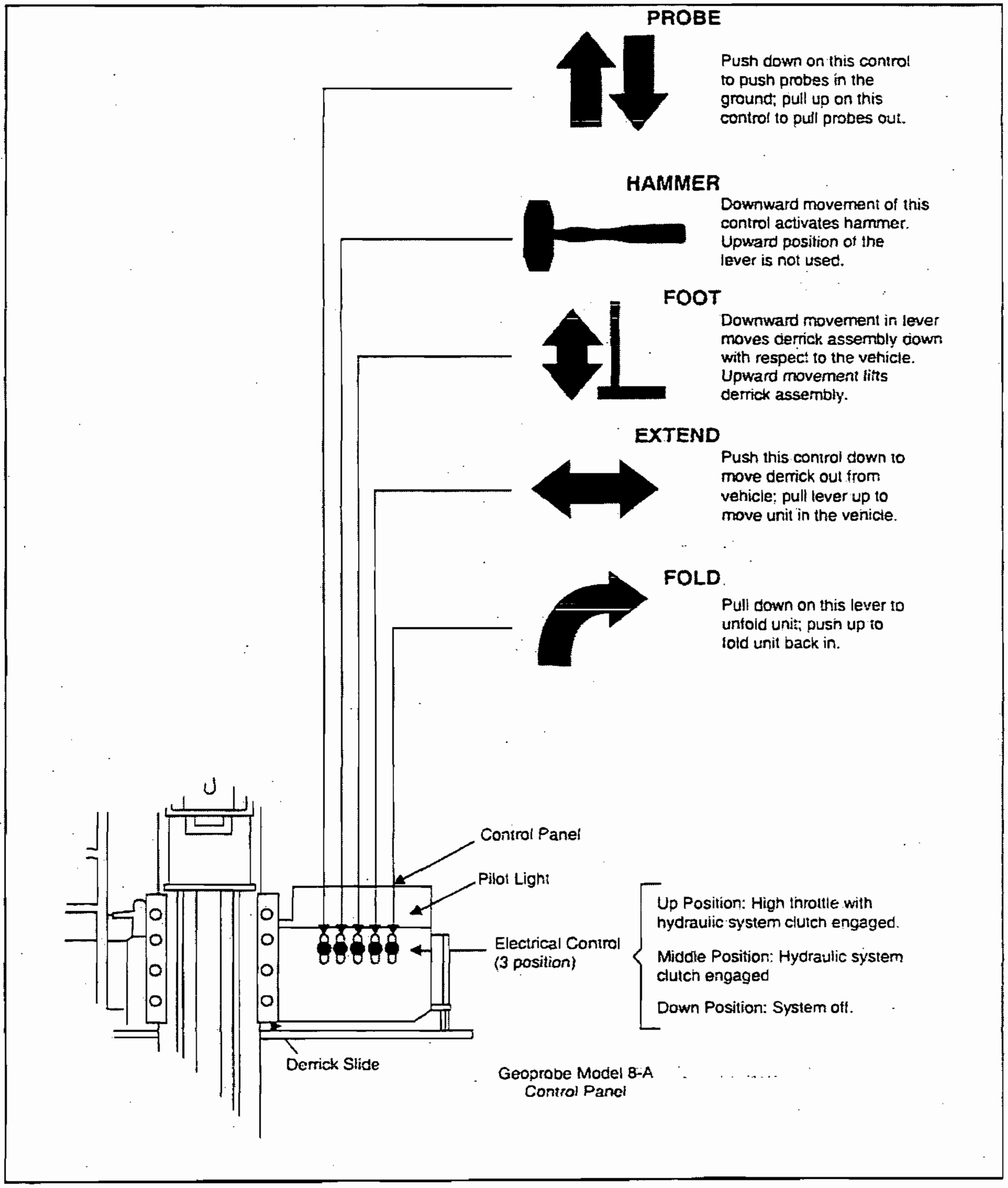

Figure 3 Geoprobe Model 8-A Control Panel

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- Adjust the derrick until it is vertical, using the lever provided to check for true vertical.

- Adjust the foot by pushing down on the FOOT lever and raising the rear bumper of the van approximately 1 foot. Do not raise the rear wheels off of the ground.

- Lift up on the PROBE lever and raise the derrick to its maximum height. Check that the derrick is true vertical and adjust as necessary.

- Shut off the hydraulics by switching the toggle switch on the control panel fully down, and secure the anvil in its cradle with the hammer latch. Never work on or in the hammer while the hydraulics are engaged.

- Assemble the desired lead rod and sampling assembly and attach a drive cap to the top of the lead rod.

- Place the toggle switch up to the slow position, and place the lead rod below the hammer assembly. The lead rod should be centered and parallel with the derrick. Push down on the PROBE lever while ensuring that the drive cap is seated in the anvil.

The Geoprobe 8-A is now ready to advance the sampler into the ground.

5.2.3 Rod Advancement

To advance the lead rod to the project depth, the following procedures should be followed when using the Geoprobe 8-A:

- With the toggle switch in the center (slow) position, the operator continues to hold the PROBE lever down. The lead rod will need to be steadied with the operator's hand until the anvil is in contact with the lead rod. Only the operator, who is handling the controls, should steady the rod or reach near the hammer assembly. The lead rod will be pushed slowly into the ground. This procedure allows the operator to gauge the soil resistance and avoid deflection.

- At the point where the lead rod does not advance and the weight of the van is placed on the rod, move the toggle switch to the full up (fast) position. Push down again on the PROBE lever and continue to push the lead rod. Allow the rear of the van to rise 6 inches off of the ground. When the weight of the van is insufficient to push the rod into the ground, push the HAMMER lever down. When the rod has advanced to the point where the derrick foot is again on the ground, release the HAMMER lever, and push the PROBE lever down until the van rises 6 inches. Repeat this process until the rod is fully driven into the ground.

- Raise the hammer anvil to its full height by lifting the PROBE lever, and turn the toggle switch to the off position. Never reach into or around the hammer anvil while the toggle switch is in the on position. The helper then removes the drive cap from the lead rod and attaches the drive cap to the next rod to be used. The helper then attaches the next 3-foot rod section to the rod that has just been driven.

- The toggle switch is raised to the fast position, and Steps 2 and 3 are repeated until the desired depth is reached. If the rods do not advance, do not attempt to force them.

The Geoprobe 8-A is now ready for the crew to perform the required sampling activities.

5.2.4 Rod Removal

After completion of the required sampling activities, the rods may be extracted from the ground by lifting the PROBE lever and raising the hammer assembly. Put the toggle switch in the off position, and lift the hammer latch to remove the anvil. Leave the hammer latch open. Once the helper has attached the pulling cap to the rod, the operator will position the toggle switch to the middle (slow) position and push the PROBE lever down and lower the hammer assembly down to the pulling cap. The operator will turn the toggle switch off and will close the hammer latch under the pulling cap. The operator will place the toggle switch in the slow position and lift the PROBE lever up to raise the hammer assembly fully up. (NOTE: The rods should never be pulled out in the fast position, as this increases the chances of breaking the hammer latch.) The operator will then push the PROBE lever down and lower the hammer assembly sufficiently to clear the pulling cap. The toggle switch is then placed in the slow position, and the PROBE lever is lifted to raise the hammer assembly fully up. The toggle switch is then placed in the off position, and the helper removes the exposed rod and attaches the pulling cap to the next rod section. The sequence is repeated until all rod sections are removed from the ground.

5.2.5 Shutdown

After the rods have been extracted from the ground, the Geoprobe 8-A is ready to be shut down and moved to the next sampling location. The following procedures should be followed when securing the Geoprobe 8-A:

- Place the toggle switch in the middle (slow) position, push the PROBE lever down, and lower the hammer assembly to the bottom of the derrick.

- Lift the FOOT lever to raise the foot completely.

- Push the EXTEND lever down to fully extend the derrick.

- Check to make sure that all hydraulic and electrical lines are clear of the derrick storage area.

- Lift the FOLD lever to fold the derrick assembly to the horizontal position.
- Lift the EXTEND lever to bring the derrick assembly forward into the van.
- Move the toggle switch to the off position to shut off the hydraulics.
- Turn off the cooling fan on the switch in the rear of the van, and shut off the engine using the remote ignition switch on the same panel.
- Remove the exhaust hose from the tailpipe, and remove the chock blocks. Close the doors to complete the shutdown.

The Geoprobe 8-A is now ready to be moved to the next location.

6. Subsurface Soil Sampling

The Geoprobe 8-A is capable of collecting discrete subsurface soil samples with a special soil sampling probe that is screwed onto the end of the lead rod. The sampler consists of the sample tube, cutting shoe, piston tip and piston rod, drive head, and a piston stop pin. A 2-foot-long acetate liner fits inside the sample tube, allowing the collection of a 2-foot-long soil sample. The following steps describe the procedures to follow when collecting soil samples:

- Assemble a clean, decontaminated soil sampler. Attach the drive head to the sample tube. Insert the acetate liner with the lip toward the cutting shoe end. Insert the piston tip and piston rod into the sample tube by feeding the piston rod through the hole in the drive head and attach the cutting shoe to the bottom of the sample tube. Ensure that the piston tip is allowed to slide downward until it is seated in the cutting shoe. Tighten the piston stop pin to complete the assembly. Note that the piston stop pin has a left-handed thread. The piston stop pin must be tight, or vibrations may cause the soil sampler to open at the wrong depth.
- Attach the 1-foot-long adapter rod, and use this assembly as the lead rod.
- Drive rods in a normal manner to the depth from where the sample is to be collected.
- When the specified sample depth is reached, raise the hammer assembly to the top of the derrick and remove the drive cap.
- Three-foot-long, threaded, 0.25-inch-diameter extension rods are used to loosen the piston stop pin. Insert the extension rods into the open drive rods, and attach each rod with a 0.25-inch-ID coupling nut. Connect as many rods as necessary to reach the piston stop pin. Attach an extension rod handle to the top of the last extension rod.

Turn the extension rod handle in a clockwise direction two to three revolutions. Attempt to lift the threaded rods; the rods cannot be lifted if they have started into the piston stop pin. Continue turning the extension rod handle clockwise until the threaded rods have been completely seated into the piston stop pin; the piston stop pin is now ready to be removed. Remove the threaded extension rods one at a time until all have been removed from the drive rods. The last threaded extension rod should have the piston stop pin attached.

- Reattach the drive cap and lower the hammer assembly.
- Advance the drive rods 2 feet.
- Extract all drive rods and remove the soil sampler.
- Repeat these steps as necessary to collect additional subsurface soil samples.

7. Groundwater Sampling

The Geoprobe 8-A is capable of collecting groundwater samples with tygon bailers or a peristaltic pump. The tygon bailers are 3/8-inch OD, which can be inserted into the drive rods. A check valve in the leading end of the bailer may be used to pump the groundwater sample from the rods, or, if soil conditions permit, the drive rods can be extracted and a 0.75-inch-OD bailer can be used in the open hole. If a peristaltic pump is used, tygon tubing is lowered down the rods into the groundwater to collect the groundwater sample. The tubing is then placed into the peristaltic pump, and the groundwater is pumped to the surface. The following steps describe the procedures to follow when collecting groundwater samples.

- The lead rod is assembled using the 2-foot slotted rod, a 1-foot adapter, and an expendable tip.
- The rods are driven in the normal manner until the slotted rod section is beneath the groundwater table.
- The drive cap is removed from the drive rod, and the pulling cap is attached.
- The rods are lifted about 1 foot, which allows the expendable tip to separate from the lead rod. Groundwater will enter the drive rod, and a groundwater sample can now be collected through the rods.
- Extract the drive rods in a normal manner.

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8. Soil-Gas Sampling

The Geoprobe 8-A is capable of collecting discrete soil-gas samples using the post-run tubing (PRT) system, which is screwed into the end of the lead rod. The PRT system consists of a PRT expendable point holder with threads for a PRT adapter, a PRT adapter, an expendable point, and disposable tubing. The following steps describe the procedures to follow when collecting soil-gas samples with the Geoprobe.

- Assemble a clean, decontaminated PRT expendable point holder to a clean, decontaminated lead rod.
- Place a rubber "O" ring on a clean, decontaminated expendable drive point, then place the drive point into the PRT expendable point holder.
- Drive rods in a normal manner to the depth from where the sample is to be collected.
- When the specified sample depth is reached, remove the drive cap and attach the pull cap. Pull the rod up approximately 1 foot. This will release the drive point and expose the open end of the PRT expendable point holder. Remove the pull cap to expose the open end of the rod.
- Attach a clean, decontaminated PRT adapter with a rubber "O" ring to the end of the tubing and then insert the tubing and the PRT adapter down the inside of the rods until the PRT comes into contact with the PRT expendable point holder.
- Cut the tubing at the surface so that there is plenty of tubing to connect to the vacuum source. Turn the tubing until the PRT adapter screws securely into the PRT point holder.
- The soil-gas sample is now extracted from the soil and into a container using a vacuum. The container (glass bulb or Tedlar bag) is placed in-line between the vacuum pump and the tubing emerging from the drive rods. The sample is then collected using a vacuum. The vacuum is generated by the on-board vacuum volume pump. This pump will allow the operator to determine the volume of vapor extracted from the soil.
- Once the soil-gas sample is collected, extract all drive rods and the PRT expendable point holder. The expendable point will remain in the ground.
- Repeat these steps as necessary to collect additional subsurface soil-gas samples.

9. Abandonment of Probe Holes

Before probe holes can be abandoned, regulations from the state in which the soil boring and well abandonment will be performed should be consulted. Each state may have specific regulations for soil boring and well abandonment, and these regulations can dictate the method and material that will be used to plug the probe holes. However, in most cases, the state will require that the probe holes be backfilled with some sort of bentonite clay (granular or a slurry).

10. References

Bergren, C.L., R.C. Tuckfield, and N.M. Park, 1990, "Suitability of the Hydropunch for Assessing Groundwater Contamination by Volatile Organics," proceedings of the Fourth National Outdoor Action Conference for Aquifer Restoration, Groundwater Monitoring and Geophysical Methods, National Water Well Association, Dublin, Ohio.

Cordry, K.E, 1986, "Groundwater Sampling Without Wells," proceedings of the Sixth National Symposium and Exposition on Aquifer Restoration and Groundwater Monitoring, National Water Well Association, Dublin, Ohio.

Ehreuzeller, J.L., F.G. Baker, and V.E. Keys, 1991, "Using the Geoprobe and Hydropunch Method to Collect Reconnaissance Groundwater Samples," *Groundwater Management*, 5:733 (5 NOAC).

Strutymsky, A.I., and T.J. Sainey, 1992, "Use of Geoprobe Penetration Testing and Penetrometry Groundwater Sampling for Volatile Organic Contaminant Plume Detection," ASTM STP 1118, American Society for Testing and Materials, Philadelphia, Pennsylvania.

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Title:	GEOLOGIC LOGGING
Category:	GEO 4.8
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STANDARD OPERATING PROCEDURE

GEOLOGIC LOGGING

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1. Introduction

Geologic logging involves keeping detailed records during the drilling of boreholes, the installation of monitoring wells, and the excavation of test pits, and entering the geologic descriptions of the soil and rock samples recovered on a standardized form. E & E has adapted a standardized geotechnical logbook (see DOC 2.4 in E & E's Standard Operating Procedures [SOPs]) that contains items deemed important to record when installing monitoring wells, piezometers, and/or soil borings. This document discusses general procedures for completing geologic logs.

2. Drilling Logs

2.1 Basic Documentation

When drilling boreholes, the project geologist should maintain a log that describes each borehole. The E & E Geotechnical Logbook contains records for boreholes. The following basic information should be entered on the heading of each drilling log sheet (see Figure 1):

- Borehole/well number;
- Project name;
- Site location;
- Dates and times that drilling was started and completed;
- Drilling company;
- E & E geologist's name;
- Drill rig type used to drill the borehole;
- Drilling method(s) used to drill the borehole;

DRILLING LOG FOR ____________

Project Name ____________

Site Location ____________

____

Date Started/Finished ____________

Drilling Company ____________

Driller's Name ____________

Geologist's Name ____________

Geologist's Signature ____________

Rig Type(s) ____________

Drilling Method(s) ____________

Bit Size(s) ________ Auger Size(s) ________

Auger/Split Spoon Refusal ____________

Total Depth of Borehole is ____________

Total Depth of Corehole is ____________

Water Level (TOIC)		
Date	Time	Level (Feet)

Well Location Sketch

N

Depth (Feet)	Sample Number	Blows on Sampler	Soil Components CL SI S GR	Rock Pile	Penetration Times	Run Number	Core Recovery	RQD	Fracture Sketch	HNu/OVA (ppm)	Comments
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											

Figure 1 Drilling Log

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- Bit and auger size(s);
- Depth of auger/split barrel sampler refusal;
- Total depth of borehole;
- Total depth of corehole (if applicable);
- Water level at time of completion measured from top of inside casing (TOIC); and
- A well location sketch.

2.2 Technical Information

During the drilling of a borehole, specific technical information about the unconsolidated material and rock encountered should be recorded on the drilling log sheet. The following minimum technical information should be recorded:

- Depth that sample was collected or encountered;
- Sample number assigned (if applicable);
- The number of blow counts required to drive the split barrel sampler 2 feet at 6-inch intervals (see Table 1);
- Description of soil components (see Figure 2);
- Description of rock profile (see Figure 3);
- Rock qualitative designation (RQD) (see Figure 4);
- Rock penetration time;
- Core run number (if applicable) and percent recovery; and
- Organic vapor readings in the sample.

Table 1 Standard Penetration Test for Soil Density

N-Blows/Feet	Relative Density
Cohesionless Soils	
0 - 4	Very loose
4 - 10	Loose
10 - 30	Medium
30 - 50	Dense
50	Very dense
Cohesive Soils	
2	Very soft
2 - 4	Soft
4 - 8	Medium
8 - 15	Stiff
15 - 30	Very stiff
30	Hard

3. Soil Classification

Soils should be described using the Unified Soil Classification System (USCS) in the narrative lithologic description section of Figure 5. Figure 6 is a summary of the American Society for Testing and Materials (ASTM) criteria for describing soils. Soil descriptions should be concise, stressing major constituents and characteristics, and should be given in a consistent order and format. The following order is recommended by the ASTM:

1. Soil name. The basic name of the predominant constituent and a single-word modifier indicating the major subordinate constituent.

2. Gradation or Plasticity. Granular soils (i.e., sands or gravels) should be described as well-graded, poorly-graded, uniform, or gap-graded, depending on the gradation of the minus 3-inch fraction. Cohesive soils (i.e., silts and clays) should be described as nonplastic, slightly plastic, moderately plastic, or highly plastic, depending on results of the manual evaluation for plasticity.

3. Particle size distribution. An estimate of the percentage and grain-size range of each subordinate constituent of the soil. This description may also include a description of angularity (see Figure 7).

4. Color. The basic color of the soil.

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SOIL AND SEDIMENT CLASSIFICATION

GRAIN-SIZE SCALE (Modified Wentworth Scale)

phi	mm	Inches	U.S. Standard Sieve Series	Grade Name		
-12	4096	161.30				
				very large		
-11	2048	80.60				
				large		
-10	1024	40.30			Boulders	
				medium		
-9	512	20.20				
				small		
-8	256	10.10				
				large		
-7	128	5.00			Cobbles	GRAVEL
				small		
-6	64	2.52	63.0 mm			
				very coarse		
-5	32	1.26	31.5 mm			
				coarse		
-4	16	0.63	16.0 mm			
				medium	Pebbles	
-3	8	0.32	8.0 mm			
				fine		
-2	4	0.16	No. 5			
				very fine		
-1	2	0.08	No. 10			
				very coarse		
0	1	0.04	No. 18			
				coarse	Sand	SAND
+1	0.500		No. 35			
				medium		
+2	0.250		No. 60			
				fine		
+3	0.125		No. 120			
				very fine		
+4	0.062		No. 230			
				coarse		
+5	0.031				Silt	
				medium		
+6	0.016					
				fine		
+7	0.008					MUD
				very fine		
+8	0.004					
				coarse		
+9	0.002					
				medium		
+10	0.001					
				fine		
+11	0.0005					CLAY SIZE
				very fine		
+12	0.00025					

PROPORTIONS USED IN DESCRIBING SOILS

Trace - Particles are present but estimated to be less than 5%
Few - 5 to 10%
Little - 15 to 25%
Some - 30 to 45%
Mostly - 50 to 100%

i.e.: Sand with a trace of silt = 95% Sand, < 5% Silt

(When sampling gravelly soils with a standard split spoon, the true percentage of gravel is often not recovered due to relatively small sample diameter.)

Soil Density from Standard Penetration Test (ASTM D1586)

Granular Soils	Cohesive Soils
0 - 10 Loose	0 - 4 Soft
10 - 30 Medium Dense	4 - 8 Medium Stiff
30 - 50 Dense	8 - 15 Stiff
Over 50 Very Dense	15 - 30 Very Stiff

CLASSIFICATION CHART (United Soil Classification System)

MAJOR DIVISIONS			Symbols	TYPICAL NAMES
Coarse Grained Soils	(More than 1/2 of soil > no 200 sieve size)	GRAVELS (More than 1/2 of coarse fraction > No. 4 sieve size)	GW	Well-graded gravels or gravel-sand mixtures little or no fines
			GP	Poorly graded gravels or gravel-sand mixtures little or no fines
			GM	Silty gravels, gravel-sand-silt mixture
			CC	Clayey gravels, gravel-sand-clay mixtures
		SANDS (More than 1/2 of coarse fraction < No. 4 sieve size)	SW	Well-graded sands or gravelly sands, little or no fines
			SP	Poorly graded sands or gravelly sands, little or no fines
			SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand clay mixtures
Fine Grained Soils	(More than 1/2 of soil < no 200 sieve size)	SILTS AND CLAYS LL< 50	ML	Inorganic silts, and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
			CL	Inorganic clays, of low to medium plasticity; gravelly clays, sandy clays, silty clays, lean clays
			OL	Organic silts and organic clays of low plasticity
		SILTS AND CLAYS LL> 50	MH	Inorganic silts, micaceous or diatomaceous, fine sandy or silty soils, elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silty clays, organic silts
HIGHLY ORGANIC SOILS			Pt	Peat and other highly organic soils

Figure 2 USCS Soil Classification Chart

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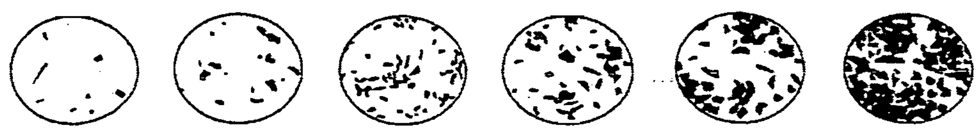
ROCK DESCRIPTIVE TERMS

Term		Defining Characteristics	
Hardness	Soft	Scratched by fingernail	
	Moderately Hard	Scratched easily by penknife	
	Hard	Difficult to scratch with a penknife	
	Very Hard	Cannot be scratched by penknife	
Weathering	Unweathered	Rock is unstained. May be fractured, but discontinuities are not stained.	
	Slighty	Rock is unstained. Discontinuities show some staining on the surfaces of rocks, but discoloration does not penetrate rock mass.	
	Moderate	Discontinuity surfaces are stained. Discoloration may extend into rock along discontinuity surfaces.	
	High	Individual rock fragments are thoroughly stained and may be crumbly.	
	Severe	Rock appears to consist of gravel-sized fragments in a "soil" matrix. Individual fragments are thoroughly discolored and can be broken with fingers.	
Bedding Planes	Laminated	< .04 in.	< 1 mm
	Parting	.04 in. - .24 in.	1mm - 6mm
	Banded	.24 in. - 1in.	6 mm - 3 cm
	Thin	1 in. - 4 in.	3 cm - 9.1 cm
	Medium	4 in. - 12 in.	9.1 cm - 30.5 cm
	Thick	12 in.- 36 in.	30.5 cm - 1m
	Massive	> 36 in.	> 1 m
Joints and Fracture Spacing	Very tight	< 2 in.	< 5.1 cm
	Tight	2 in. - 1ft.	5.1 - 30.5 cm
	Moderately tight	1ft. - 3 ft.	30.5 cm - 91.4 cm
	Wide	3 ft. - 10 ft.	91.4 cm - 3 M
	Very wide	> 10 ft.	> 3 M
Voids	Porous	Smaller than a pinhead. Their presence is indicated by the degree of absorbency.	
	Pitted	Pinhead size to a 1/4 inch. If only thin walls separate the individual pits, the core may be described as honeycombed.	
	Vug	1/4 inch to the diameter of the core. The upper limit will vary with core size.	
	Cavity	Larger than the diameter of the core.	

Rock Particle Percent Composition Estimation



1% 5% 10% 15% 25% 50%

Figure 3 Rock Descriptive Terms

ROCK QUALITY DESIGNATION (RQD) AND FRACTURE FREQUENCY

Core borings are a useful means of obtaining information about the quality of rock mass. The recoverable core indicates the character of the intact rock and the number and character of the natural discontinuities.

Another quantitative index that has proved useful in logging NX core is a rock quality designation (RQD) developed by Deere (1963). The RQD is a modified core recovery percentage in which all the pieces of sound NX core over 4 inches long are counted as recovery. The length of the core run is the distance to the nearest tenth of a foot from the corrected depth of the hole at the end of the previous run to the corrected depth of the hole at the end of subject run. The smaller pieces are considered to be due to close shearing, jointing, faulting, or weathering in the rock mass and are not counted. The RQD is a more general measure of the core quality than the fracture frequency. Core loss, weathered and soft zones, as well as fractures, are accounted for in this determination. The RQD provides a preliminary estimate of the variation of the <u>in situ</u> rock mass properties from the properties of the "sound" portion of the rock core. Thus, a general estimate of the behavior of the rock mass can be made. An RQD approaching 100 percent denotes an excellent quality rock mass with properties similar to that of an intact specimen. RQD values ranging from 0 to 50 percent are indicative of a poor quality rock mass having a small fraction of the strength and stiffness measured for an intact specimen.

RQD (Rock Quality Designation)

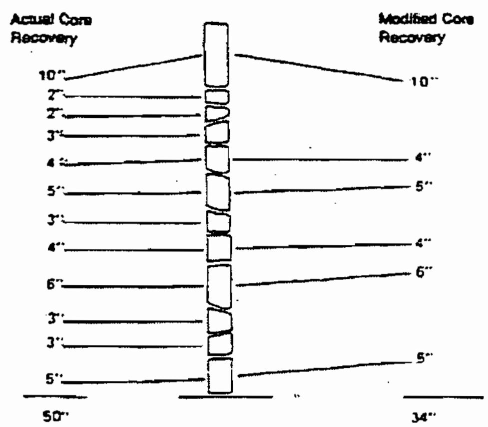
0 - 25	Very Poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 - 100	Excellent

An example of determining the RQD from a core run of 60 inches measured from corrected depth to corrected depth is given in Diagram 1. For this particular case, the core recovery was 50 inches and the modified core recovery was 34 inches. This yields an RQD of 57 percent, classifying the rock mass in the fair category.

Problems arise in the use of RQD for determining the in situ rock mass quality. The RQD evaluates fractures in the core caused by the drilling process, as well as in natural fractures previously existing in the rock mass. For example, when the core hole penetrates a fault zone or a joint, additional breaks may form that, although not natural fractures, are caused by natural planes of weakness existing in the rock mass. These fresh breaks occur during drilling and handling of the core and are not related to the quality of the rock mass. The skill of the driller will affect the amount of breakage and the core loss that occurs. Poor drilling techniques will "penalize" the rock by lowering its apparent quality. It is difficult to distinguish between drilling breaks and those natural and incipient fractures that reflect the quality of the rock mass. In certain instances, it may be advisable to include all fractures when estimating RQD. Obviously, some judgement is involved in core logging.

Another problem with the use of the RQD index is that the determinations are not sensative to the tightness of the individual joints, whereas in some instances, the <u>in situ</u> deformation modulus may be strongly affected by the average joint opening.

RQD OF A SINGLE CORE RUN*



Core Run 60"
(Corrected depth to corrected depth)

$\frac{34"}{60"}$ x 100% = 57% = Fair

* Typical calculation of RQD of a single core run. Note that the run is calculated from corrected depth to corrected depth.

Figure 4 Rock Qualitative Designation (RQD)

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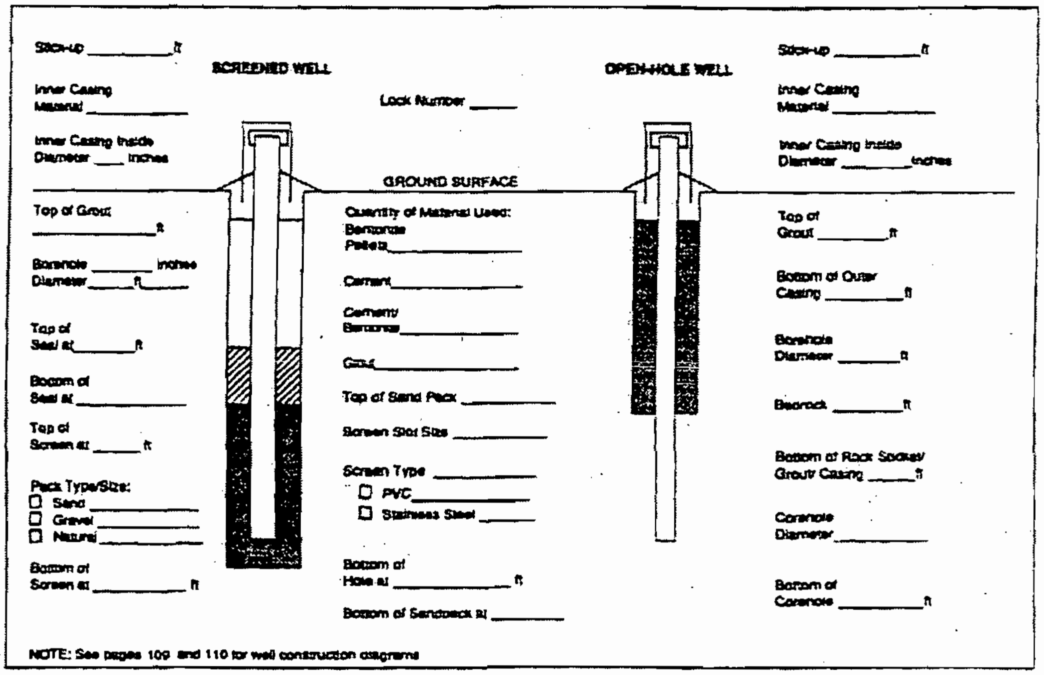

Depth-ft.	NARRATIVE LITHOLOGIC DESCRIPTION	Moisture Content: Dry	Moist	Wet
		○	○	○
1		○	○	○
2		○	○	○
3		○	○	○
4		○	○	○
5		○	○	○
6		○	○	○
7		○	○	○
8		○	○	○
9		○	○	○
10		○	○	○
11		○	○	○
12		○	○	○
13		○	○	○
14		○	○	○

Figure 5 Narrative Lithologic Description

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ASTM CRITERIA FOR DESCRIBING SOIL

Criteria for Describing Angularity of Coarse-Grained Particles

Description	Criteria
Angular	Particles have sharp edges and relatively plane side with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved side and no edges

Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

Criteria for Describing Toughness

Description	Criteria
Low	Only slight pressure is required to roll the thread near the plastic limit . The thread and the lump are weak and soft.
Medium	Medium pressure is required to roll the thread to near plastic limit. The thread and the lump have medium stiffness.
High	Considerable pressure is required to roll the thread to near the plastic limit. The thread and the lump have very high stiffness.

Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with mere pressure of handling
Low	The dry specimen crumbles into powder with some finger pressure
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very High	The dry specimen cannot be broken between the thumb and shard surface

Criteria for Describing Structure

Description	Criteria
Stratified	Alternating layers of varing material or color with layers at least 6 mm thick; note thickness.
Laminated	Alternating layers of varying materials or color with the layers less than 6 mm thick; note thickness.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, sometimes striated.
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown.
Lensed	Inclusion of small pockets of different soils, such as small lenses of sand scattered through a mass of clay; note thickness.
Homogeneous	Same color and appearance throughout.

Figure 6 ASTM Criteria For Describing Soil

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CRITERIA FOR DESCRIBING SOIL (Cont.)

Criteria for Describing the Reaction with HCl

Description	Criteria
None	No visible reaction
Weak	Some reaction, with bubbles forming slowly
Strong	Violent reaction, with bubbles forming immediately

Criteria for Describing Consistency

Description	Criteria
Very Soft	Thumb will penetrate soil more than 1 inch (25 mm)
Soft	Thumb will penetrate soil about 1 inch (25 mm)
Firm	Thumb will indent soil about 1/4 inch (6 mm)
Hard	Thumb will not indent soil but readily indented with thumbnail
Very Hard	Thumbnail will not indent soil

Criteria for Describing Cementation

Description	Criteria
Weak	Crumbles or breaks with handling or little finger pressure
Moderate	Crumbles or breaks with considerable finger pressure
Strong	Will not crumble or break with finger pressure

Criteria for Describing Particle Shape

The particle shape shall be described as follows where length, width, and thickness refer to greatest, intermediate, and least dimensions of a particle, respectively (see page 104).

Flat	Particles with width/thickness ratio > 3
Elongated	Particles with length/width ratio > 3
Flat and Elongated	Particles meet criteria for both flat and elongated

Criteria for Describing Plasticity

Description	Criteria
Nonplastic	A 1/8 inch (3 mm) thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Identification of Inorganic Fine-Grained Soils from Manual Tests

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	None to low	Slow to rapid	Low or thread cannot be formed
CL	Medium to high	None to slow	Medium
MH	Low to medium	None to slow	Low to medium
CH	High to very high	None	High

Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

Figure 6 ASTM Criteria for Describing Soil (cont.)

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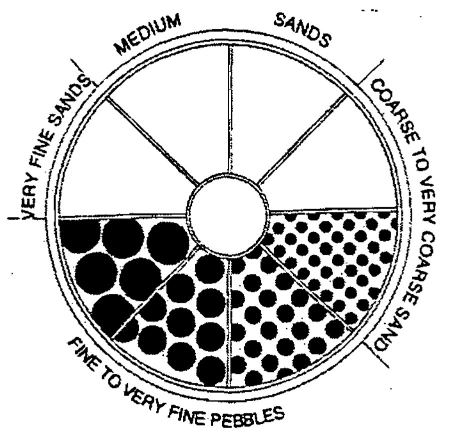
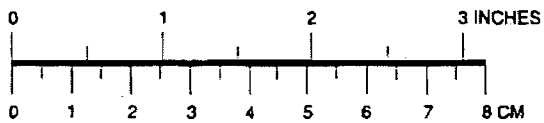
SEDIMENT PARTICLE SIZE AND SHAPE ESTIMATES

GRAPH FOR DETERMINING SIZE OF SEDIMENTARY PARTICLES





COBBLES RANGE FROM 6.4 TO 25.6 cm (~2.5 TO 10.1 INCHES)
BOULDERS ARE LARGER THAN 25.6 cm (>10.1 INCHES)

SEDIMENT PARTICLE SHAPES

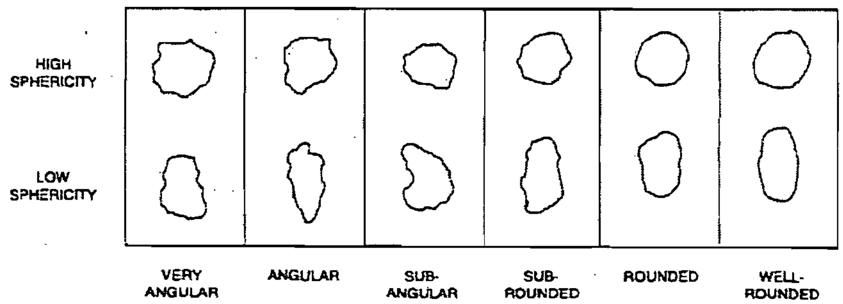


Figure 7 Sediment Particle Size and Shape Estimates

5. Moisture content. The amount of soil moisture (dry, moist, or wet).

6. Relative density or consistency. An estimate of density of a granular soil or consistency of a cohesive soil, usually based on the standard penetration test results (see Table 1).

7. Soil Structure or Mineralogy. Description of discontinuities, inclusions, and structures. Includes joints, fissures, and slickensides.

4. Core Logging

4.1 Handling of Core

After the core has been recovered from the corehole and the core barrel has been opened, the core should be placed in a core box. The top of the core should be placed at the back left corner of the core box, and the remaining core placed to the right of the preceding section (see Figure 8). The core box should be filled in this manner, moving to the front sections of the core box. The beginning of each run should be marked on the core and also noted with a marked wooden block.

4.2 Rock Description

Each stratigraphic unit in the core shall be logged. A line marking the depth of the top and the bottom of the unit shall be drawn horizontally. In classifying the rock, the geologist should avoid being too technical, as the information presented must be used by numerous people with widely divergent backgrounds.

The classification and description of each unit should be given in the following order, as applicable:

1. Unit designation (Miami oolite, Clayton Formation, Chattanooga shale);

2. Rock type;

3. Hardness;

4. Degree of weathering;

5. Texture;

6. Structure;

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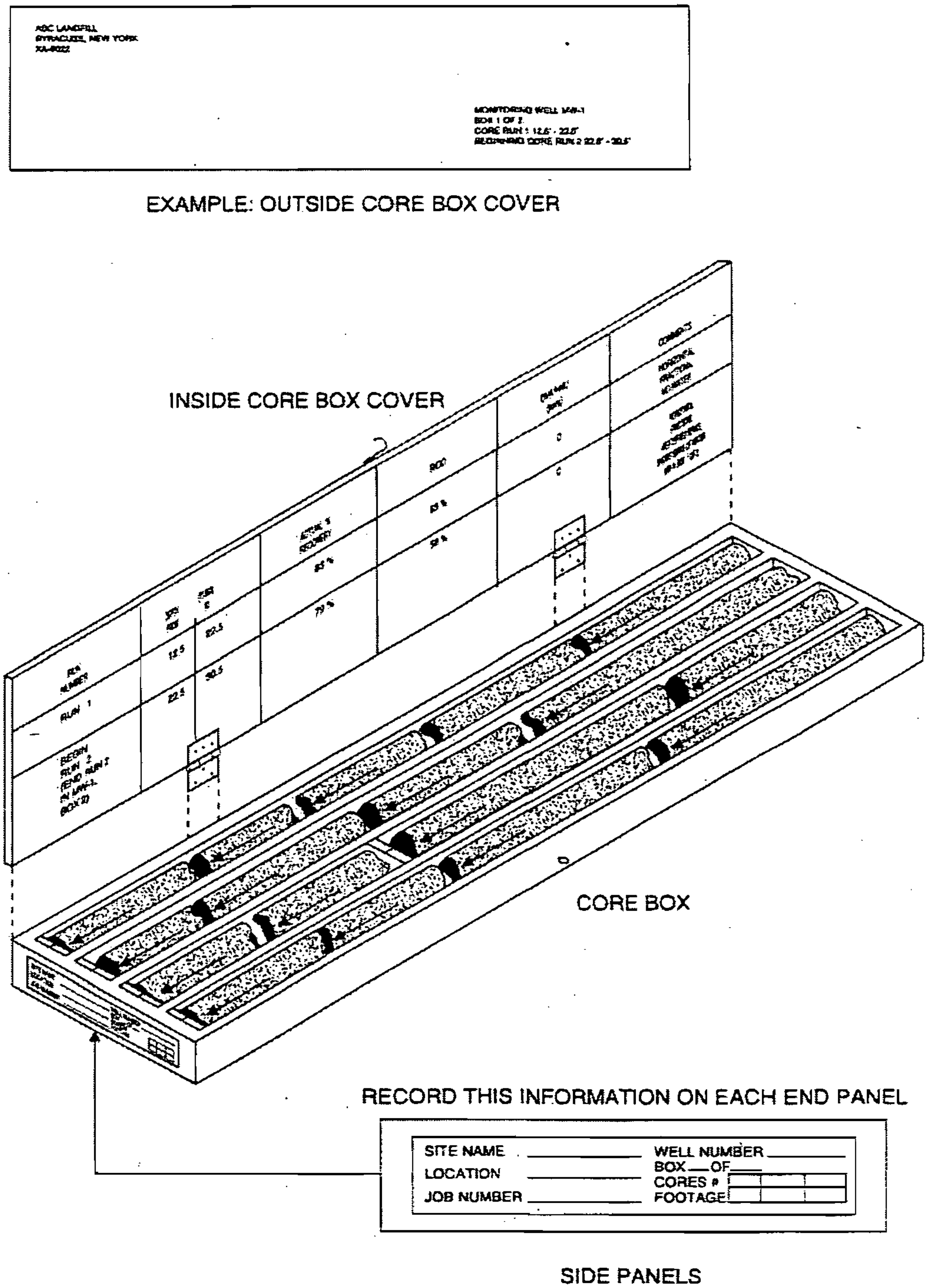

Figure 8 Core Box

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7. Color;

8. Solution and void conditions;

9. Swelling properties;

10. Slaking properties; and

11. Additional description, such as mineralization, size, and spacing shale seams, etc.

Variations from the general description of the unit and features not included in the general description shall be indicated by brackets and lines to show the depth and the interval in the core where the feature exists. These variations and features shall be identified by terms that will adequately describe the feature or variation so as to delineate it from the unit. These may be zones or seams of different color, texture, etc., from that of the unit as a whole, such as staining; variations in texture; shale seams, gypsum seams, chert nodules, calcite masses, etc.; mineralized zones; vuggy zones, joints, fractures; open and/or stained bedding planes; faults, shear zones, gouge; cavities' thickness, open or filled, nature of filling, etc.; or any core left in the bottom of the hole after the final pull.

Rock Type and Lithology

1. Rock will be classified according to the following 24 types:

   - Sandstone
   - Conglomerate
   - Coal
   - Compaction Shale
   - Cemented Shale
   - Indurated Clay
   - Limestone
   - Chalk
   - Gneiss
   - Schist

- Graywacke
- Quartzite
- Dolomite
- Marble
- Soapstone and Serpentine
- Slate
- Granite
- Diorite
- Gabbro
- Rhyolite
- Andesite
- Basalt
- Tuff or Tuff Breccia
- Agglomerate or Flow Breccia

2. Lithologic characteristics should be included to differentiate rocks of the same classification. These adjectives should be simple and easily understood, such as shaly, sandy, dolomitic, etc. Inclusions, nodules, and concretions should also be noted here.

3. It is important to maintain a simple but accurate rock classification. The rock type and lithologic characteristics are essentially used to differentiate the rock units encountered.

Hardness

The terms for hardness, as outlined below, were modified to include the use of a rock hammer.

1. **Very soft** or plastic - can be deformed by hand (has a rock-like character but can be broken easily by hand).

2. **Soft** - can be scratched with a fingernail (cannot be crumbled between fingers but can be easily pitted with light blows of a geology hammer).

3. **Moderately hard** - can be scratched easily with a knife; cannot be scratched with a fingernail (can be pitted with moderate blows of a geology hammer).

4. **Hard** - difficult to scratch with a knife (cannot be pitted with a geology hammer but can be chipped with moderate blows of the hammer).

5. **Very hard** - cannot be scratched with a knife (chips can be broken off only with heavy blows of the geology hammer).

Weathering

The degree and depth of weathering is very important and should be accurately detailed in the general description and clearly indicated on the drill log.

1. **Unweathered** - no evidence of any mechanical or chemical alteration.

2. **Slightly weathered** - superficial discoloration, alteration, and/or discoloration along discontinuities; less than 10% of the rock volume is altered; strength is essentially unaffected.

3. **Moderately weathered** - discoloration is evident; surface is pitted and altered, with alterations penetrating well below rock surfaces; 10% to 50% of the rock is altered; strength is noticeably less than unweathered rock.

4. **Highly weathered** - entire section is discolored; alteration is greater than 50%; some areas of slightly weathered rock are present; some minerals are leached away; retains only a fraction of its original strength (wet strength is usually lower than dry strength).

5. **Decomposed** - saprolite; rock is essentially reduced to a soil with a relic rock texture; can be molded or crumbled by hand.

Texture

Texture is used to denote the size of the grains or crystals comprising the rock, as opposed to the arrangement of the grains or crystals, which is considered a structure.

1. **Aphanitic** - grain diameter less than 0.004 inch (0.1 mm); individual grains or crystals are too small to be seen with the naked eye.

2. **Fine-grained, finely crystalline** - grain diameter between 0.004 inch (0.1 mm) and 0.003 (1 mm); grains or crystals can be seen with the naked eye.

3. **Medium-grained, crystalline** - grain diameters between 0.003 foot (1 mm) and 0.0175 foot (5 mm).

4. **Coarse-grained, coarsely crystalline** - grain diameter greater than 0.0175 foot (5 mm).

Structure

The structural character of the rock shall be described in terms of grain or crystal alignment, bedding, and discontinuities, as applicable. The terms may be used singularly or paired.

1. **Foliation and/or lineation** - give approximate dip uniformity, degree of distinctiveness, banding, etc.

2. **Joints:**
   a. Type - bedding, cleavage, foliation, extension, etc.
   b. Degree of openness - tight or open.
   c. Surface or joint plane characteristics - smooth, rough, undulating.
   d. Weathering - degree, staining.
   e. Frequency - see (4).

3. **Fractures, shears, gouge:**
   a. Nature - single plane or zone. (Note thickness.)
   b. Character of materials in plane or zone.
   c. Slickensides.

4. **Frequency:**
   a. Intact - spacing greater than 6 feet (2 m).
   b. Slightly jointed (fractured) - spacing 3 feet (1 m) to 6 feet (2 m).
   c. Moderately jointed (fractured) - spacing 1 foot (0.3 m) to 3 feet (1 m).
   d. Highly jointed (fractured) - spacing 0.3 foot (9.1 cm) to 1 foot (0.3 m).
   e. Intensely jointed (fractured) - spacing less than 0.3 foot (9.1 cm).

5. **Bedding** is used to describe the average thickness of the individual beds within recognized unit, and the terms thick, medium, or thin should not be applied to the individual beds. "Parting" and "band" are used to describe single stratum as outlined below:
   a. Massive - over 3 feet thick (1 m).
   b. Thick - 1 foot (30.5 cm) to 3 feet (1 m) thick.
   c. Medium - 0.3 foot (9.1 cm) to 1 foot (30.5 cm) thick.
   d. Thin - 0.1 foot (3.0 cm) to 0.3 foot (9.1 cm) thick.

e. Band - 0.02 foot (6 mm) to 0.1 foot (3.0 cm) thick, described to the nearest 0.01 foot.
f. Parting - less than 0.02 foot (6 mm).
g. Paper-thin parting.

The terms and descriptions for the structure of the rock are to be used to describe the character of the rock units recognized and are not to be used as a substitute for describing individual discontinuities. Except for areas where the rock is intensely fractured or jointed, each discontinuity should be described on the log as to position, dip, staining, weathering, breccia, gouge, etc.

Color is often valuable in correlating or differentiating samples, but can be misleading or uninformative. The color of a sample should represent the sample in terms of basic hues (i.e., red, blue, gray, black), supplemented with modifying hues as required (i.e., bluish gray, mottled brown). The core should be surface wet when describing the color; if it is dry, the log should indicate "dry color." Subjective colors, such as buff or maroon, should not be used. Specific color charts, such as the Mumsel Color Chart or the Color Index in the Colorado School of Mines, Quarterly, Volume 50, No. 1, are useful in describing color of samples. When such a chart or index is used, it should be noted on the log in the remarks column.

Solution and Void Conditions shall be described in detail, as these features can affect the strength of the rock and can indicate potential seepage paths through the rock. When cavities are detected by drill action, the depth to top and bottom of the cavity should be determined by measuring the stick-up of the drill tools when the cavity is first encountered and again at the bottom, as it is very difficult to reconstruct cavities from the core alone. Filling material, when present and recovered, should be described in detail opposite the cavity. When no material is recovered from the area of the cavity, the inspector should note the probable conditions of the cavity as determined from observing the drilling action and the color of the drill fluid. If the drill action indicated material was present (i.e., slow rod drop, no loss of drill water, noticeable change in color of water return), it should be noted on the log that the cavity was probably filled and the materials should be described as best as possible from the cuttings or traces left on the core. If drill action indicates the cavity was open (i.e., no resistance to the drill tools, loss of drill fluid), this should be noted on the drill log. Partially filled cavities should also be noted. All of these observations require close observation of the drill action and water return by both the inspector and the driller; accurate measurement of stick-ups; and detailed inspection of the core. When possible, filling material should be wrapped in foil if left in the core box. If the material is to be tested or examined in the lab, it should be sealed in a jar with proper labels and a spacer, with a note showing the disposition of the material should be placed in the core box at the point from which the material was taken. Terms to describe voids encountered shall be as follows:

1. **Porous** - voids less than 0.003 foot (1 mm) in diameter.

2. **Pitted** - voids 0.03 foot (1 mm) to 0.02 foot (6 mm) in diameter.

3. **Vug** - voids 0.02 foot (6 mm) to the diameter of the core.

4. **Cavity** - voids greater than diameter of the core.

4.3 Core Labeling

The top of the core should be shown on each piece of core with an arrow written in a black, waterproof marker. The arrow will indicate which end of the core is nearer the ground surface. Other core markings may include locations of mechanical breaks and drilling footages.

4.4 Core Box Labeling

Each core box should be labeled as follows:

- On the top left corner of the outer core box, the project name, site location (city and state), and project number should be written.
- On the lower right corner of the outer core box, the corehole number (e.g., MW1, BH2), core box number (e.g., 1 of 2, 2 of 2), and the interval of the core run contained in the core box should be written.
- The side panels should be marked as indicated in Figure 8.
- The inside of the core box cover should be marked as indicated in Figure 8.

4.5 Core Storage

It is important to use proper-sized (HQ or NQ) wooden core boxes for rock core storage. After labeling the box and before closing the box for final storage or shipment, wooden spacers should be inserted into each compartment that contains rock core. This will prevent lateral movement of the cores, which could damage the rock material during handling.

After properly logging, labelling, and packing the cores, the core boxes should be stored in a dry location, preferably off of the floor on a pallet. The boxes can be stacked to a reasonable height so as not to be unstable, with end labelling facing out.

5. References

American Society for Testing and Materials (ASTM), 1975, Test Method for Classification of Soils for Engineering Purposes, ASTM D2487-69, Philadelphia, Pennsylvania.

__________, 1975, Recommended Practice of Description of Soils, ASTM D2488-69, Philadelphia, Pennsylvania.

Deere, D.V., 1963, Technical Description of Rock Cores for Engineering Purposes: Rock Mechanics and Engineering Geology, Vol. 1, No. 1, pp. 16-22.

Dow Chemical, 1980, Field Data Handbook, Dowell Division of Dow Chemical Company, Houston, Texas.

Driscoll, J.T., R.V. Dietrich, and R.M. Foose, 1989, AGI Data Sheets for Geology in the Field, Laboratory, and Office, Third Edition, American Geological Institute, Alexandria, Virginia.

U.S. Army Corps of Engineers, St. Louis District, Inspector's Manual, St. Louis, Missouri.

U.S. Environmental Protection Agency (EPA), 1986, RCRA Groundwater Monitoring Technical Enforcement Guidance Document, Washington, D.C.

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Title:	HEALTH AND SAFETY ON DRILLING RIG OPERATIONS
Category:	H&S 5.3
Revised:	September 2008

STANDARD OPERATING PROCEDURE

HEALTH AND SAFETY ON DRILLING RIG OPERATIONS

ecology and environment, inc.
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1. Introduction

This document is meant to be used in conjunction with Ecology and Environment, Inc., (E & E) standard operating procedures (SOPs) for field operations and hazardous waste site operations, and incorporates by reference all safety precautions required therein. It specifically addresses the functions and responsibilities of personnel working on or around drilling operations.

E & E personnel are frequently required to oversee a subcontractor's work in the field using drill rigs to take soil and rock samples, and install piezometers and monitoring wells. This document discusses the supervision of subcontract drillers by E & E.

2. Responsibilities and Authority of Subcontract Driller

The subcontract driller has authority to direct its personnel within the area while drilling operations are in progress. Access to the hazardous area around the auger and borehole is restricted by a "super exclusion zone" delineated by a 4-foot by 8-foot sheet of plywood centered over the borehole before drilling. A large hole cut in the plywood allows penetration of the augers. No E & E personnel are allowed in this "super exclusion zone" at any time while drilling is underway.

Housekeeping around the rig is the responsibility of the driller, but all team members should, when necessary, participate in this effort.

2.1 Responsibility and Authority of E & E Personnel

E & E personnel working at a drilling site must act as support to the subcontract drilling team by providing any necessary support functions; however, it is important that E & E personnel are careful not to interfere with the drilling process. Personnel are restricted from approaching the "super exclusion zone" while drilling is underway. If an E & E crew member recognizes an unsafe condition in the work area or on the rig, he should bring it to the attention of the site safety officer (SSO) and team leader if it is not resolved in a timely manner by the subcontractor driller. If conditions are still deemed to be hazardous, team members have the option of contacting their regional safety coordinator (RSC) or Corporate Health and Safety Group in Buffalo.

It is the responsibility of all E & E personnel to have with them on site their issued non-disposable gear, including hard hat, face shield, respirator, steel-toed boots, eyepiece inserts, safety glasses, and appropriate outerwear for the expected weather. It is the E & E employee's responsibility to ensure that all of his/her equipment is in proper working order.

All personnel should be aware of emergency facilities, egress routes, and special medical conditions of their team members. As with all E & E fieldwork, the buddy system is to be enforced.

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3. Training Requirements for Site Personnel

3.1 E & E Site Safety Officer

In addition to basic health and safety training, annual health and safety refresher training, first aid, cardiopulmonary resuscitation (CPR), and necessary training in field monitoring of personnel, an SSO should have previous experience as a team member on field drilling projects in order to have a working knowledge of the drill rig and the extreme hazards that can occur with its operation. Where monitoring instrumentation is to be used, the SSO must be properly trained prior to fieldwork. The SSO must have an understanding of the hazards of heat and cold stress, their associated symptoms, and proper work modifications to protect field staff from potential injury.

3.2 Other E & E Personnel

All E & E personnel present on site shall have taken the basic 40-hour health and safety course and annual 8-hour refresher training course. Field personnel also must meet medical and respiratory fitness test requirements established by E & E and Occupational Safety and Health Agency (OSHA).

3.3 Subcontract Driller and Other Subcontract Drilling Personnel

Subcontract drillers and their support personnel on site must, at a minimum, have passed basic 40-hour health and safety training as prescribed by OSHA 29 Code of Federal Regulations (CFR) 1910.120. They shall be medically approved and trained to use the level(s) of respiratory protection required on site. Certification of training by the subcontractor shall be required as a deliverable included in E & E's contractual documentation. This training shall be verbally verified and logged on site by the SSO or team leader before starting work.

4. Supervision of Subcontract Drillers

4.1 Responsibilities and Authority of Site Safety Officer

The responsibilities of the SSO at a drilling site where subcontracted drillers are used include the following: rig inspections, personnel monitoring, and personnel protection.

A rig inspection should begin by verifying the following:

- The mast must be located at least 25 feet from any overhead or underground utility lines;
- The location and operation of operational and unencumbered kill switches must be reiterated to all site personnel;

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- Outriggers, stabilizers, or jacks are in place, and the rig is level;
- A geophysical survey (e.g., electromagnetic or ground-penetrating radar) or a reliable site history must be obtained to verify the absence of underground utilities, buried obstacles, tanks, and drums;
- A first aid kit and filled eyewash bottle must be readily available;
- A fire extinguisher should be charged to the proper pressure and placed at the rear of the rig during drilling;
- The condition of ropes, chains, and cables must be checked;
- A lifeline or safety belt must be available if mast climbing is necessary;
- The Site Safety Plan (SSP) must be posted with emergency phone list and map of hospital route; and
- A "super exclusion zone" must be established around the borehole, using traffic cones or a 4-foot by 8-foot sheet of plywood. This defined area will be entered during active drilling only by the subcontract driller and his helper(s), except in emergency situations.

If, upon review, the SSO deems that any material item noted above requires replacement or repair, the SSO must make necessary the arrangements for that repair or replacement, and later verify that repair or replacement is sufficient before actual drilling begins. Similarly, if the conditions listed above are not met, the SSO must request that they be met to his satisfaction before allowing drilling to proceed. Working together, the SSO and the subcontract driller should verify that the rig has been checked against the operator's checklist.

The SSO's monitoring duties include calibration and setup of the appropriate monitoring devices, as specified in the SSP. At a minimum, this generally includes an O_2/explosimeter and real-time organic-vapor monitoring capabilities (e.g., HNU, organic vapor analyzer [OVA]). Noise and heat-stress monitoring are employed where appropriate. If the SSO believes additional monitoring devices beyond the directive of the SSP should be employed (e.g., Rad Mini, Mini Ram), it is his/her responsibility to obtain this equipment from the nearest E & E office through the cooperation of the RSC or the Corporate Health and Safety Group. The SSO is also responsible for ensuring that a trained operator for this additional equipment is on site.

It is the responsibility of the SSO to ensure that all safety equipment is in good working order. Day-to-day operations, as well as calibration data, must be recorded in the equipment log or SSO log. Adequate supplies such as breathing air, drinking liquids, and calibration gas must be maintained.

E & E personnel are forbidden from entering the "super exclusion zone" around the borehole while drilling is underway. The SSO must not attempt to take air readings in or around the auger while it is in use, or from cutting samples while the auger is in motion. If possible, an

O_2/explosimeter should be set up for unmanned (alarmed) operations at the rig, using an extension hose to continuously draw samples from the borehole area during drilling operations.

The SSO has ultimate authority over the subcontractor with regard to whether work practices meet the requirements of the SSP. Shutdown of work or restriction of personnel are options available to the SSO. The SSO should hold informal site safety briefings at the start of both fieldwork and daily work shifts throughout the course of the project. Although E & E contractually requires subcontractors to provide properly trained and outfitted staff, the SSO should verify verbally at the start-up meeting that the field staff has necessary respiratory approval and OSHA-mandated training, especially at hazardous waste sites. Site safety briefing topics, as well as the names of attendees, will be recorded in the site safety log.

If the SSO has reason to believe that either E & E or subcontractor personnel are under the influence of alcohol or drugs, or are otherwise ill before or during work on site, he or she should consider restricting those team members from site work. Personnel who are to perform work that requires Level C protection must be clean-shaven or they may be restricted at the discretion of the SSO.

The following is a list of basic topics to be discussed at site safety meetings:

- Personnel responsibilities;
- Planned investigation and presumed potential hazards;
- Levels of protection, monitoring plan, and equipment;
- Emergency scenario plans, including use of kill switches;
- Location and operation of kill switches, fire extinguisher, and first aid kits;
- Heat and cold stress hazards;
- "Super exclusion zone" around borehole; and
- Warnings to subcontractors about hazards of climbing the mast without proper safety equipment.

Because heat stress is a constant threat during warm weather, the SSO is responsible for determining whether conditions are unsuitable for work. If site conditions require the assistance of work modifications, cooling vests, and other cooling means, the SSO may decide that work should not continue. The need for worker monitoring through blood pressure and oral temperature checks will be determined by the SSO with assistance from the RSC and Corporate Health and Safety Group staff, if necessary.

The SSO will be responsible for shutting down the drilling operation if electrical storms occur in the site area.

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No refueling operations will be performed until rig engines are shut down. Motor fuels should be stored and dispensed from spring-loaded, OSHA/Factory Mutual-approved metal or polyethylene gas cans.

The SSO should ensure and document that no boreholes are left open or unfilled after drilling equipment is moved. In instances where a hole must be left open and unattended, suitable barricades or the equivalent will be staged around the hole to prevent personnel and equipment from falling in.

4.2 Responsibilities and Authority of Other E & E Personnel

All E & E personnel on site are required to follow the terms of the SSP and the direction of the SSO. Because the SSO cannot be in all places at all times, the crew should observe the subcontractors and condition of their equipment at all times, and report immediately to the team leader and SSO any safety-related issues that are unresolved. Included are such details as dressout, site functions, and decontamination. It is important that the SSO be involved so that proper log entries can be made.

It is a policy of E & E not to provide safety equipment or monitoring instrumentation to subcontractors. Some projects, however, may be arranged in such a manner that allows E & E personnel and subcontractors to share the same expendable supplies.

E & E personnel are forbidden from approaching augers during drilling. Activities at the borehole, such as sampling, require that the operation of equipment be stopped.

5. Drilling Hazards

5.1 General Drilling Hazards

Drilling operations present numerous health and safety hazards to site personnel, subcontractor drillers, and members of the public who may approach the rigs. Drilling hazards that apply to all drilling methods and possible control methods include:

- Slip/trip/fall hazards;
- Ergonomic hazards;
- Moving objects;
- Unguarded points of operation;
- Heat/cold stress;
- Noise;
- Buried or overhead utilities;

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- Radiological hazards;
- Lightning;
- Chemical hazards; and
- Biological hazards.

5.2 Physical Hazards (Slip/Trip/Fall Hazards)

Personnel may be injured if they trip over tools or objects, walk on uneven terrain, fall from heights or into holes, or slip on surfaces.

Controls

- Store all tools and supplies away from the super exclusion zone;
- Personnel should use caution when walking on uneven surfaces so that they do not lose their balance;
- Subcontractor drillers must wear a lifeline or safety belt if mast climbing is necessary;
- Boreholes should be barricaded or marked with flags when drilling has been completed to prevent personnel from stepping in the hole; and
- Soil or sand should be applied to wet or slippery surfaces.

5.3 Ergonomic Hazards

Muscle strains, sprains, and injuries can occur when personnel use improper lifting methods, lift objects that are too heavy, improperly reach for objects, or work in awkward positions.

Controls

- Lift with the back as straight as possible, bend the knees, and keep the object close to the body;
- Use two people to move heavy objects such as augers;
- Avoid excessive stretching of the arms when picking up objects; and
- Avoid sudden twisting of the back or working in awkward positions.

5.4 Moving Objects

Site personnel may be injured if they are struck by debris from the borehole or by drilling machinery or components.

Controls

- Wear the appropriate personal protective equipment such as safety boots, safety glasses, and a hard hat; and
- Adequate inspection and maintenance of the drill rig will reduce the likelihood of worn equipment or parts falling and causing accidents.

5.5 Unguarded Points of Operation

The spinning auger on a drill rig or the V-belt drive on a motor are unguarded points of operation that can pull site personnel into the machinery and cause serious injuries.

Controls

- Mechanical guards cannot be placed around the spinning auger on a drill rig. Site personnel must stay away from the spinning auger and avoid wearing loose clothing that could get caught in the auger; and
- Mechanical guards must be placed over V-belt drives.

5.6 Heat/Cold Stress

Drilling is a strenuous job, and heat stress is a major hazard in hot, humid environments, especially when personnel are wearing protective equipment such as coveralls, gloves, boots, and respirators. Cold injury can occur at low temperatures and when the wind-chill factor is low.

Heat Stress

Controls

- Recognize the signs and symptoms of heat stress;
- Monitor workers who are wearing protective clothing; and
- Provide fluid replacement and schedule rest periods in cool locations.

Cold Stress

Controls

- Recognize the signs and symptoms of cold stress;
- Personnel must wear appropriate clothing during cold weather; and
- A warm rest location and fluid replacement should be provided.

5.7 Noise

Excessive noise can cause hearing damage, distract workers, and interfere with communications.

Controls

- In excessive noise areas, wear the hearing protection recommended by the SSO.

5.8 Buried or Overhead Utilities

Contact of drilling tools with electric, gas, steam, process, or other utility lines can result in fires, explosions, electric shock hazards, burns, etc.

Controls

- The boom on the drill rig must be kept at least 25 feet from overhead and buried utilities;
- After buried utilities have been located using an appropriate geophysical survey, the line locations should be marked with flags. Maps of underground utilities should also be checked, if available, to verify locations; and
- Drilling operations should proceed slowly in areas near buried utilities, as the actual utility location may not exactly correspond to the area identified by a flag or as illustrated on a map.

5.9 Radiological Hazards

5.9.1 Nonionizing Radiation

Nonionizing radiation is radiation that emits photon energy that is not sufficient to produce ionization in biological systems. Radio frequencies (including radar and microwave), infrared, visible light, and ultraviolet regions of the electromagnetic spectrum are considered to be nonionizing. Ultraviolet radiation from the sun is usually the major nonionizing radiation hazard present during drilling operations. Ultraviolet radiation can damage the skin and eyes. Potential effects include, but are not limited to, sunburn, skin cancer, photosensitization, and cataracts.

Controls

- Wear sunscreen on all exposed skin areas; and
- Wear safety glasses that block ultraviolet radiation (or sunglasses worn over safety glasses).

5.9.2 Ionizing Radiation Hazards

Ionizing radiation is electromagnetic or particulate radiation with sufficient energy to ionize atoms. Ionizing radiation may be present on some drilling sites and includes:

- Electromagnetic radiation
  - Gamma rays
  - X-rays
- Particulate radiation
  - Alpha
  - Beta
  - Neutrons

Controls

Site personnel can minimize their exposure to external radiation hazards by:

- Limiting exposure time;
- Increasing the distance from the radiation source; and
- Shielding the radiation source.

Some radiation sources can enter the body through inhalation, ingestion, and/or skin contact. Exposure can be controlled through the wearing of personal protective equipment and thorough washing of skin surfaces with soap and water.

5.10 Lightning Hazard

The elevated mast on a drill rig is a potential target of lightning.

Controls

- The SSO will halt drilling operations when electrical storms approach the drilling location.

5.11 Chemical Hazards

Chemical contaminants may be present in the form of gases, vapors, aerosols, fumes, liquids, or solids. Site personnel may be exposed to these contaminants through one or more of the following pathways: inhalation, ingestion, skin, and/or eye contact.

Controls

- Become familiar with the specific drilling operation being used to identify and avoid chemical discharge locations;
- Wear appropriate personal protective equipment;
- Practice contamination avoidance; and
- Stay upwind during grout mixing (silica inhalation hazard).

5.12 Biological Hazards

Biological hazards that may be present during drilling operations include poisonous plants, animals, and insects, and infectious agents.

Controls

- Wear insect repellant at sites where biting insects are prevalent;
- Learn to identify poisonous plants that cause dermatitis, such as poison ivy and poison oak;
- Wear impervious personal protective clothing (e.g., saranex coveralls, latex booties, nitrile surgical gloves) if work must be conducted in areas where site personnel will contact poisonous plants; and
- Avoid potential animal nesting areas and animal carcasses.

6. Drilling Methods and Hazards

6.1 Solid Flight and Bucket Augers

Solid-flight augers (also referred to as solid-stem augers, continuous flight augers, and disk augers) use solid-stem auger sections, with the flighting (curved corkscrew-like blades) connected end-to-end to the cutting head (see Figure 1). Soil cuttings are moved upward to the ground surface by the flighting as the auger penetrates into the soil. Samples are typically collected by removing an auger section, attaching a split-spoon or thin-wall sampler to the end of a drill rod, and placing this arrangement into the borehole. Split-spoon samples are collected by using a hammer connected to the drill rod and split-spoon. The hammer is operated by wrapping sections of rope around a rotating cathead hoist (a wide metal cylinder). A disk auger is similar to a solid-flight auger except that it is larger in diameter and the flighting goes around the stem once. Bucket augers have a cutting edge on the bottom. Once the bucket auger fills with soil cuttings, it is brought to the surface to be emptied. Figure 1 shows various types of bucket augers.

Auger drill methods are used in unconsolidated material for sampling subsurface media, installing groundwater monitoring wells, and identifying depth to bedrock.

6.2 Hollow-Stem Auger

A drill rig rotates a hollow-stem auger (see Figure 2) and moves it vertically into the soil. The hollow stem allows use of continuous or intermittent soil sampling techniques. Once the required depth has been reached, screens and casing for monitoring wells can be placed in the hollow-stem gravel pack and grout is added as the auger is pulled out of the borehole. Hollow-stem auger drilling is a common method of monitoring well installation.

6.2.1 Auger Drilling Hazards

Physical Hazards

Spinning Auger. The spinning auger is not equipped with a metal guard; therefore, it is imperative that personnel use extreme caution when working near spinning auger, as contact with the auger can cause personnel to be pulled into the auger and crushed between the auger and the drill rig. Only approved drillers will remain in proximity to the borehole during drilling, and an approximate 4- by 8-foot "super exclusion area" will be established by placing a 4- by 8-foot sheet of plywood over the borehole, or by placing flagging or traffic cones around a 4- by 8-foot perimeter. No personnel, except the driller and the driller's helper, will enter this zone during drilling. The SSO will issue warnings to those personnel not authorized to enter this zone.

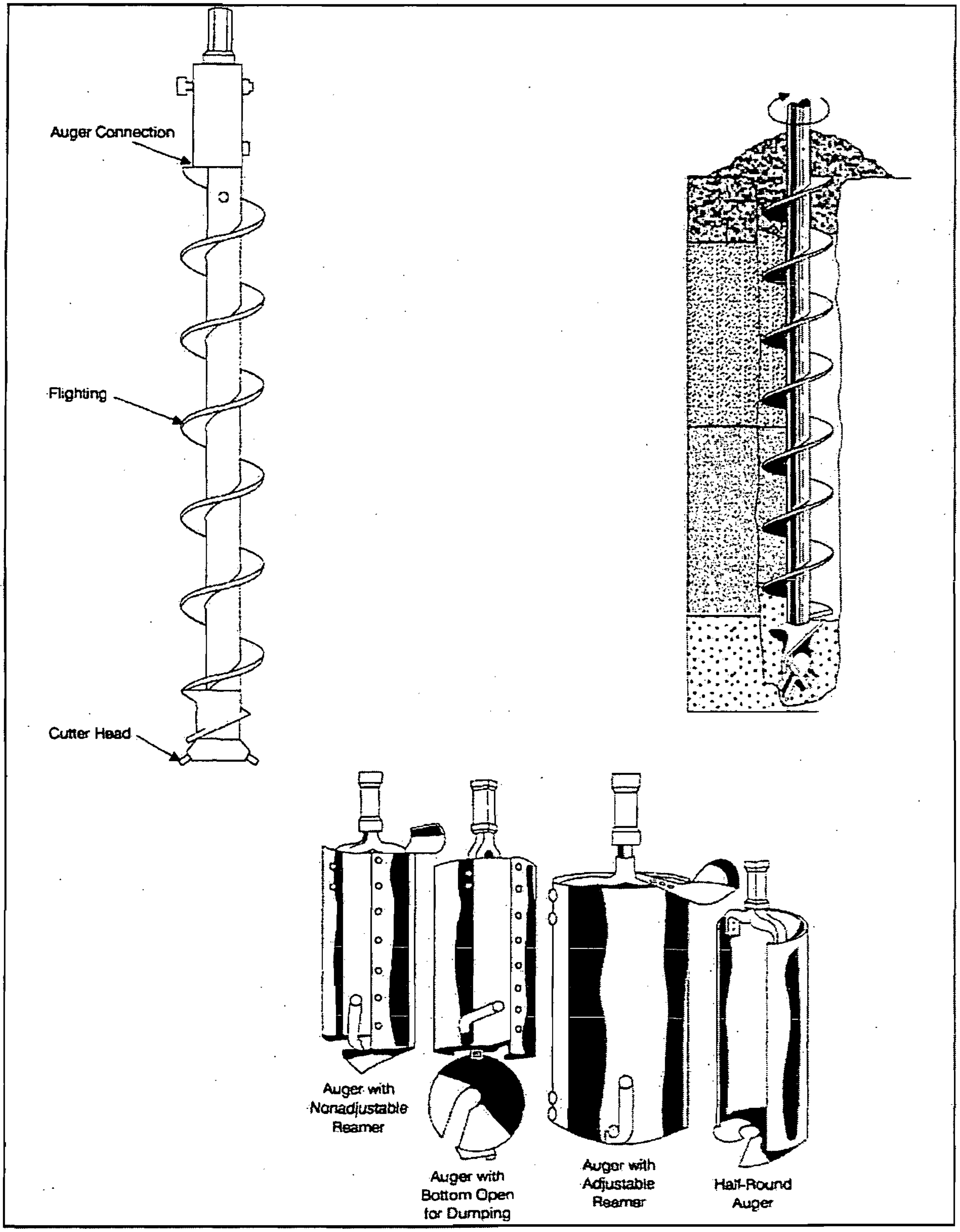

Figure 1 Solid Flight and Bucket Augers

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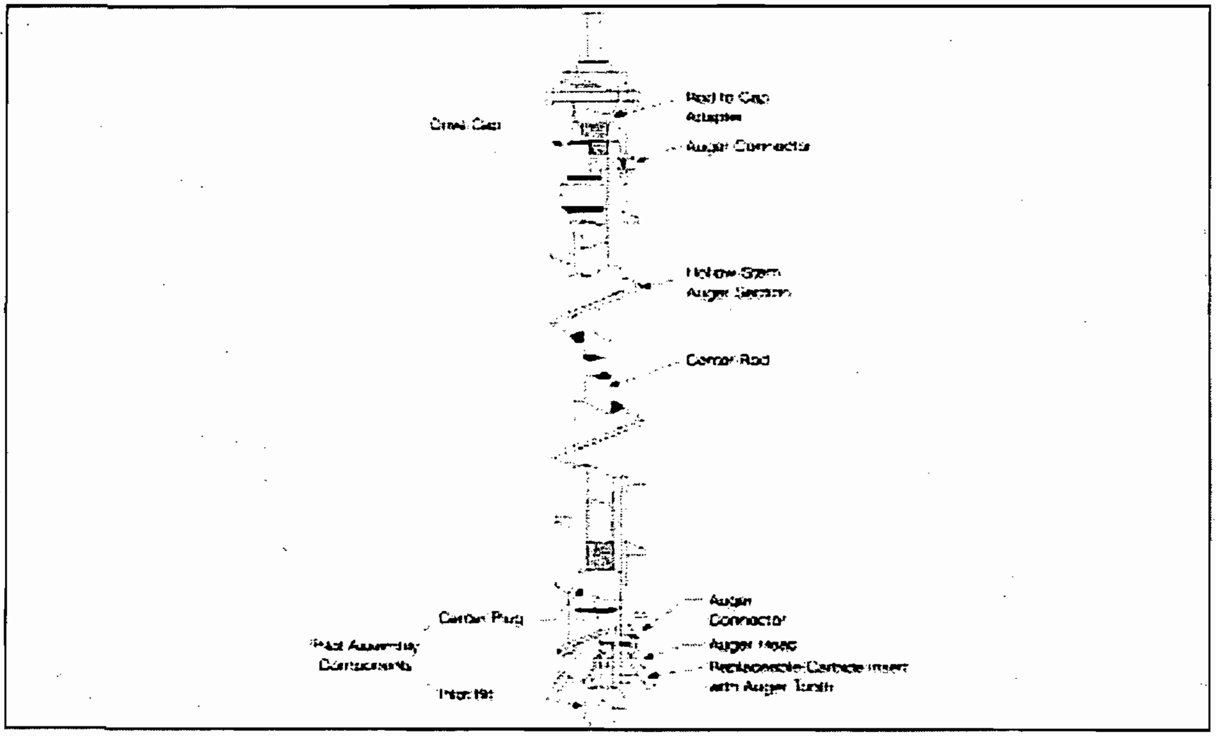

Figure 2 Hollow-Stem Auger

Overhead Equipment. If wire line core sampling is conducted, drill steel and sampling gear will be lifted overhead. Site personnel must conduct the necessary equipment inspections to ensure it is in good condition prior to the start of drilling operations. In addition, drillers must make sure that proper hoisting procedures are used to reduce the likelihood of dropping drill steel or sampling gear.

Drill Rig Lurching. The drill rig has a tendency to lurch and shake when the auger comes into contact with harder materials. This is especially true when hollow-stem auger drilling methods are utilized. The rig can also lurch seriously in hearing sands. Site personnel should be aware of possible drill rig movement and move away from the rig if lurching or shaking occurs.

Noise. If split-spoon sampling is conducted, a hammer is used to drive the spoon into the soil. The hammer generates a loud noise when it contacts a metal surface. Site personnel are required to wear appropriate hearing protection during hammering operations.

6.3 Open-Hole Rotary Methods

A direct mud rotary drilling system (also direct [liquid] rotary, hydraulic rotary, or reverse [circulation] rotary) is shown in Figure 3. Drilling fluid (mud) is pumped through drill rods to a bit. The mud flows back to the surface through the space between the drill rods and the borehole and is discharged at the surface through a pipe into a tank, tub, pond, or pit. After the cuttings settle, a pump recirculates the liquid back through the drill rods. The mud serves to:

- Cool and lubricate the bit;
- Stabilize the borehole well; and
- Prevent the inflow of fluids from formations.

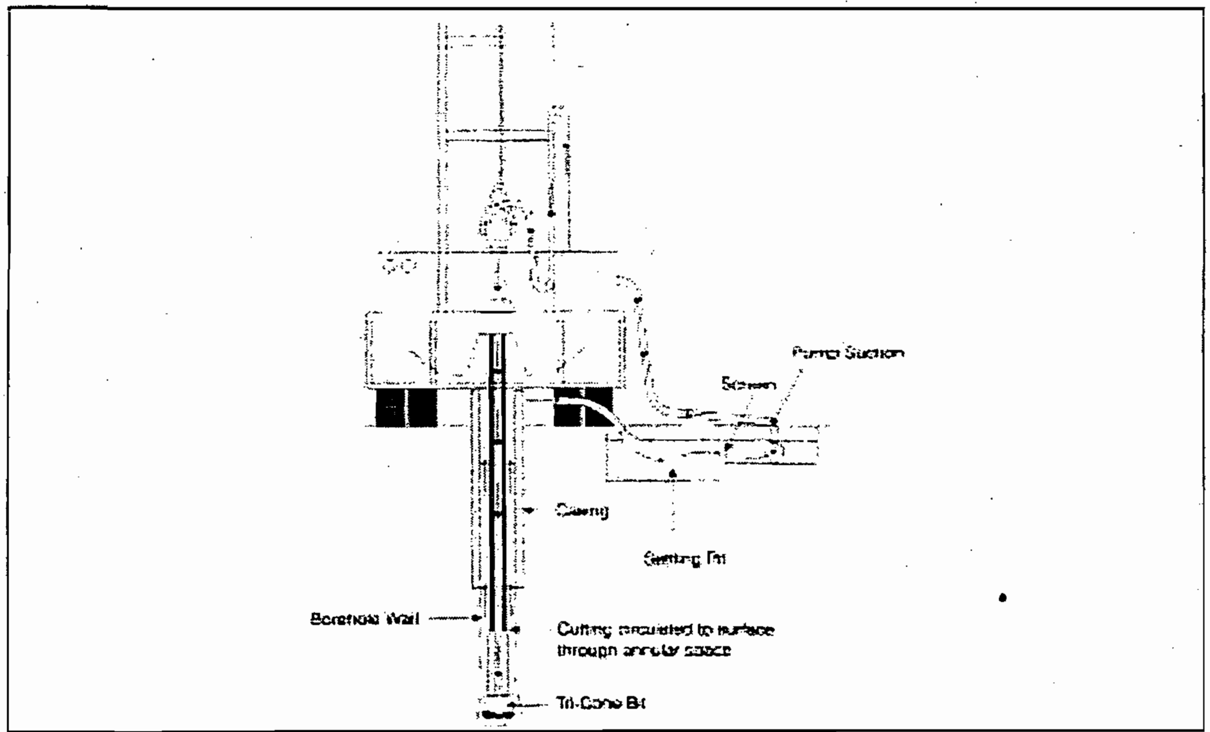

Figure 3 Open-Hole Rotary Method

A shale shaker can collect a sample from the circulated fluid by placing it in the discharge flow before the settling pit. In addition, the drilling fluid flow can be shut off and split-spoon, thing-wall, or consolidated-core samplers can be used to collect a sample by inserting a sampler through the drill rods. Reverse circulation rotary drilling is a variation of mud rotary drilling in that the mud flows from the mud pit down the borehole outside the drill rods, passes up through the bit carrying cuttings into the drill rods, and is then discharged into the mud pit. The equipment used is similar to the direct mud rotary method, except most of the equipment is larger.

Equipment Breaks. A break in support equipment for drill steel could cause equipment to fall and injure site personnel. Equipment inspection is required to ensure it is in good condition prior to the start of drilling operations.

Slippery Conditions. Because the use of drilling mud will create slippery conditions around the drill rig and support area, mud should be contained to the immediate work area. Slippery spots should be dried with sand/dirt to reduce slipping hazards. Gloves should be changed when they become coated with mud.

6.4 Direct Air Rotary with Rotary Bit/Downhole Hammer

Also called an air rotary with roller-cone (tri-cone) bit, down-the-hole hammer, or air percussion rotary, the rig setup for air rotary with a tri-cone or roller-cone bit is similar to direct mud rotary (see Figure 3), except the method uses air instead of water and drilling mud. The main components of a drill string using a tri-cone bit are illustrated in Figure 4. Compressed air is forced down through the drill rods to cool the bit, and cuttings are carried up the open hole to the surface. A cyclone slows down the air velocity, forcing the cuttings into the container. A roller-cone drill bit is used for hard-to-soft consolidated rock and unconsolidated formations. When a downhole hammer is utilized, it replaces the roller-cone bit (see Figure 4). The hammer produces a pounding action as it rotates. Other features are similar to the rotary bit, except small amounts of surfactant and water are used for dust and bit temperature control.

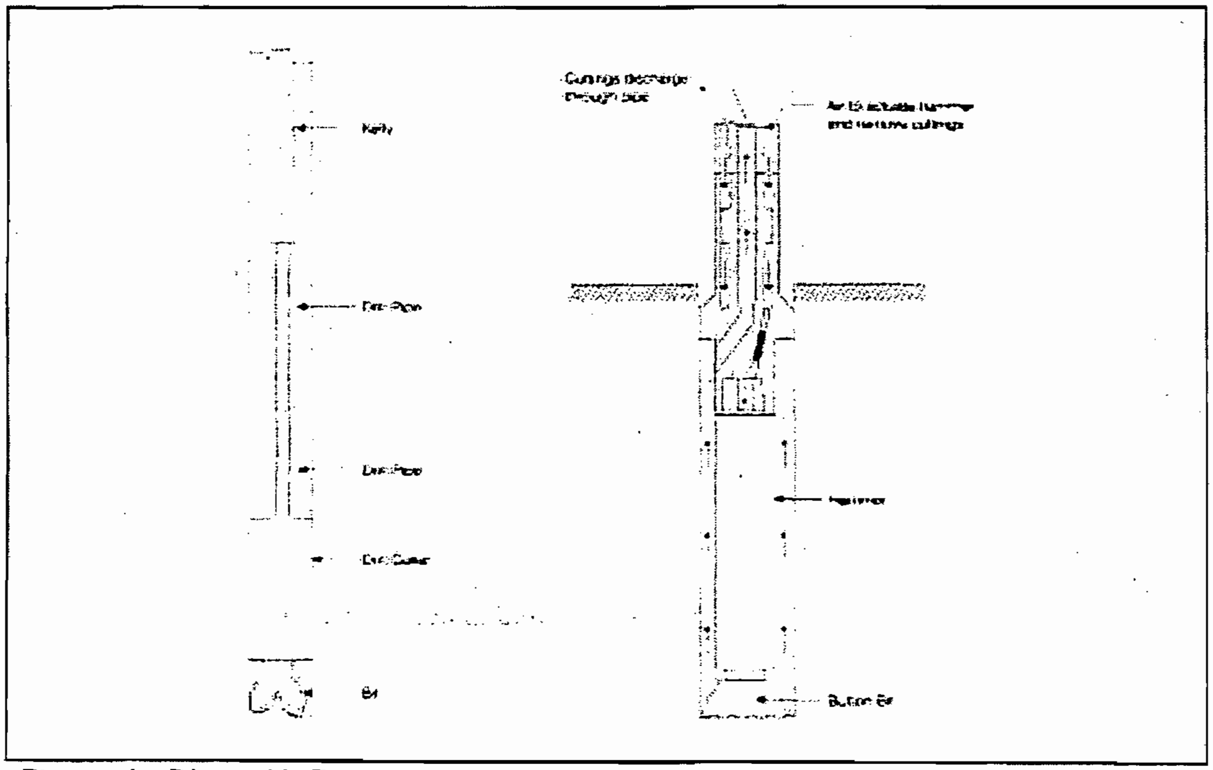

Figure 4 Direct Air Rotary

Physical Hazards

Noise. Excessive noise is generated from the use of air compressors, casing drivers, and downhole hammers. Site personnel are required to wear hearing protection during drilling operations.

Cuttings and Water. Cuttings and water blown from the hole can strike and injure site personnel. Site personnel must stay away from this discharge location and wear appropriate personal protective equipment.

Overhead Equipment. If wire line core sampling is conducted, drill steel and sampling gear will be lifted overhead. Site personnel must conduct the necessary equipment inspections to ensure it is in good condition prior to the start of drilling operations. In addition, drillers must make sure that proper hoisting procedures are followed to reduce the likelihood of falling drill steel or sampling gear.

6.5 Cable Tool

A cable tool drill rig operates by repeatedly lifting and dropping tools attached to a cable into a borehole. Figure 5 shows the components of a cable tool rig. This drilling method crushes rock and a spudding beam mixes the crushed particles with water. The water and debris is removed by a bailer or pump. In unconsolidated formations, a casing is driven into the ground. In consolidated formations, drilling is conducted with the use of a casing.

Physical Hazards

Noise. The spudding beam generates excessive noise. All personnel must wear appropriate hearing protection during drilling operations.

Rig Movement. The drill rig tends to lurch as the drill string is raised and lowered. Site personnel must maintain an adequate distance from the rig during drilling operations.

Overhead Equipment. Drill string and bailers are hoisted during drilling operations and present an overhead hazard to site personnel if a tool falls from a height.

6.6 Casing Advancement: Rotary Drill-Through Methods

6.6.1 Drill-Through Casing Driver and Dual Rotary Method

Casing drivers advancement (also referred to as air [mud] rotary drill or downhole hammer with casing drivers, air rotary casing hammer, and air drilling with casing hammer) involves a driver that moves the casing as drilling occurs (see Figure 6) during the use of conventional direct air (mud) or downhole hammer equipment. Drill cuttings move upward in the space between the drill pipe and the casing. The diameter of the casing is slightly larger than the bit so it can be easily removed.

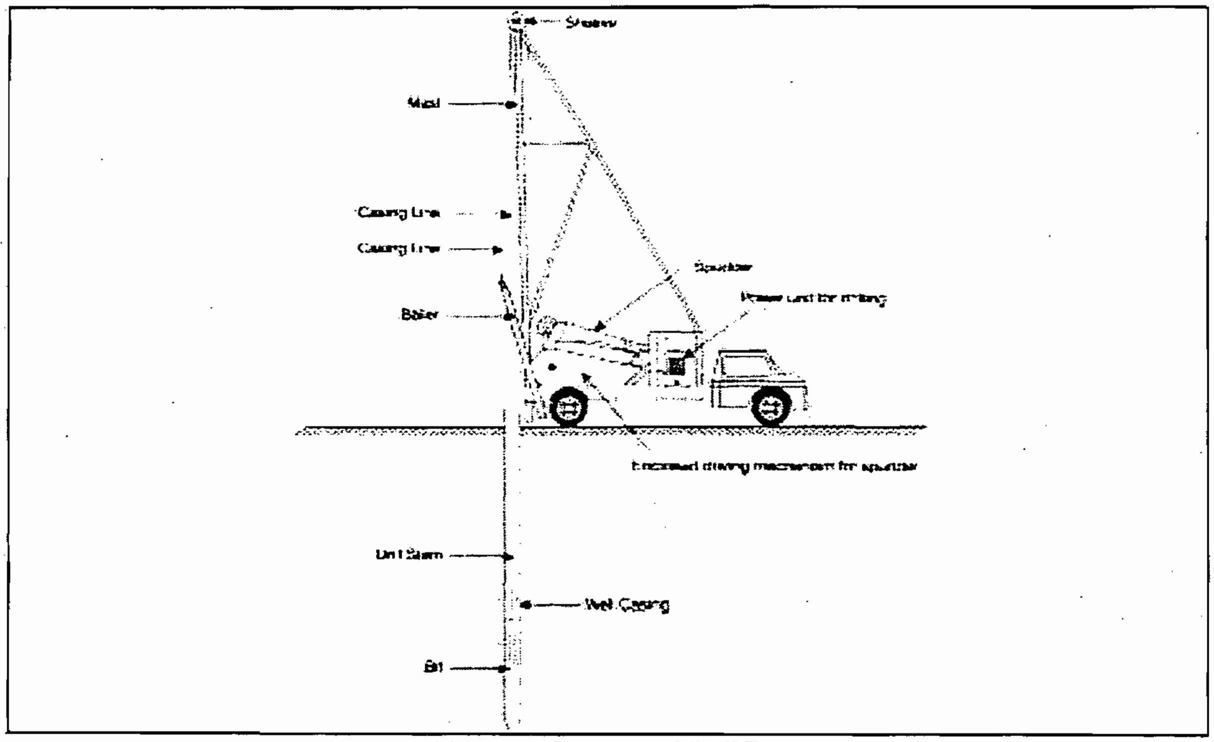

Figure 5 Cable Tool Drill Rig

In dual rotary advancement, the casing is moved by using a rotary steel casing provided with a carbide-studded drive shoe. The carbide ring cuts through the overburden material. Rotary drilling (usually air) takes place at the same time using a downhole hammer or tri-cone bit. Drilling can be conducted either inside or ahead of the casing.

The type of drilling is used to install monitoring wells in unconsolidated formations, where loss of circulation of drilling fluids is a problem, and/or where prevention of cross-contamination of aquifers is important.

6.6.2 Reverse Circulation (Rotary, Percussion Hammer, and Hydraulic Percussion)

The reverse-circulation rotary drilling method can utilize air rotary with a downhole hammer or bit or mud rotary. Two or three casings can be used.

Reverse circulation dual-wall rotary. This method is similar to downhole hammers with a casing driver or air rotary-cone bit, except air is moved down the space between the casing and the drill pipe to the bit, and soil cuttings are pushed to the surface through the drill pipe (see Figure 7).

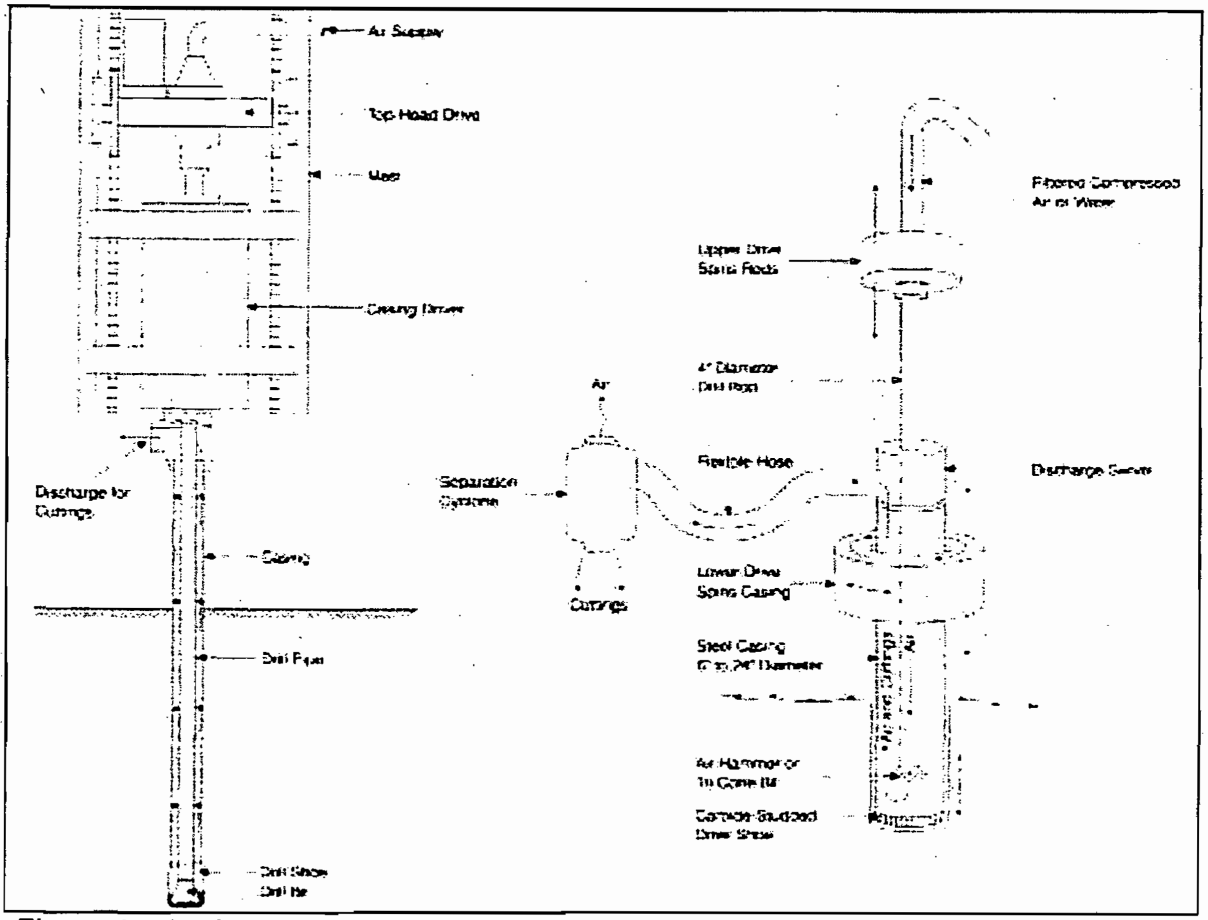

Figure 6 Casings

Reverse circulation dual-wall percussion hammer. The percussion hammer operates in a similar manner of reverse circulation as the dual-wall rotary method, except the drive method is different. Either two or three casings are used. Compressed air is moved into the space between the outer and inner pipes, and soil cuttings are discharged from the inner pipe to a cyclone. A percussion hammer on the most of the drill rig strikes an anvil on the top of the drive assembly. Two or three casings are driven, and the bit does not rotate.

Physical Hazards – Reverse Circulation Dual-Wall Rotary

Noise. Excessive noise is generated from the use of air compressors, casing drivers, and downhole hammers. Site personnel are required to wear hearing protection during drilling operations.

Cuttings. Cuttings and debris discharged from the hole can strike and injure site personnel. Site personnel must stay away from the discharge point and wear appropriate personal protective equipment.

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Overhead Equipment. If wire line core sampling is conducted, drill steel and sampling gear will be lifted overhead. Site personnel must conduct the necessary equipment inspections to ensure it is in good condition prior to the start of drilling operations. In addition, drillers must make sure that proper hoisting procedures are followed to reduce the likelihood of dropping drill steel or sampling gear.

Physical Hazards – Hydraulic Percussion

Slips/Falls. Site personnel can slip on wet ground around the drill rig or fall into the water tank. Site personnel must keep the drilling location clear of debris and contain spillage prior to and during drilling operation.

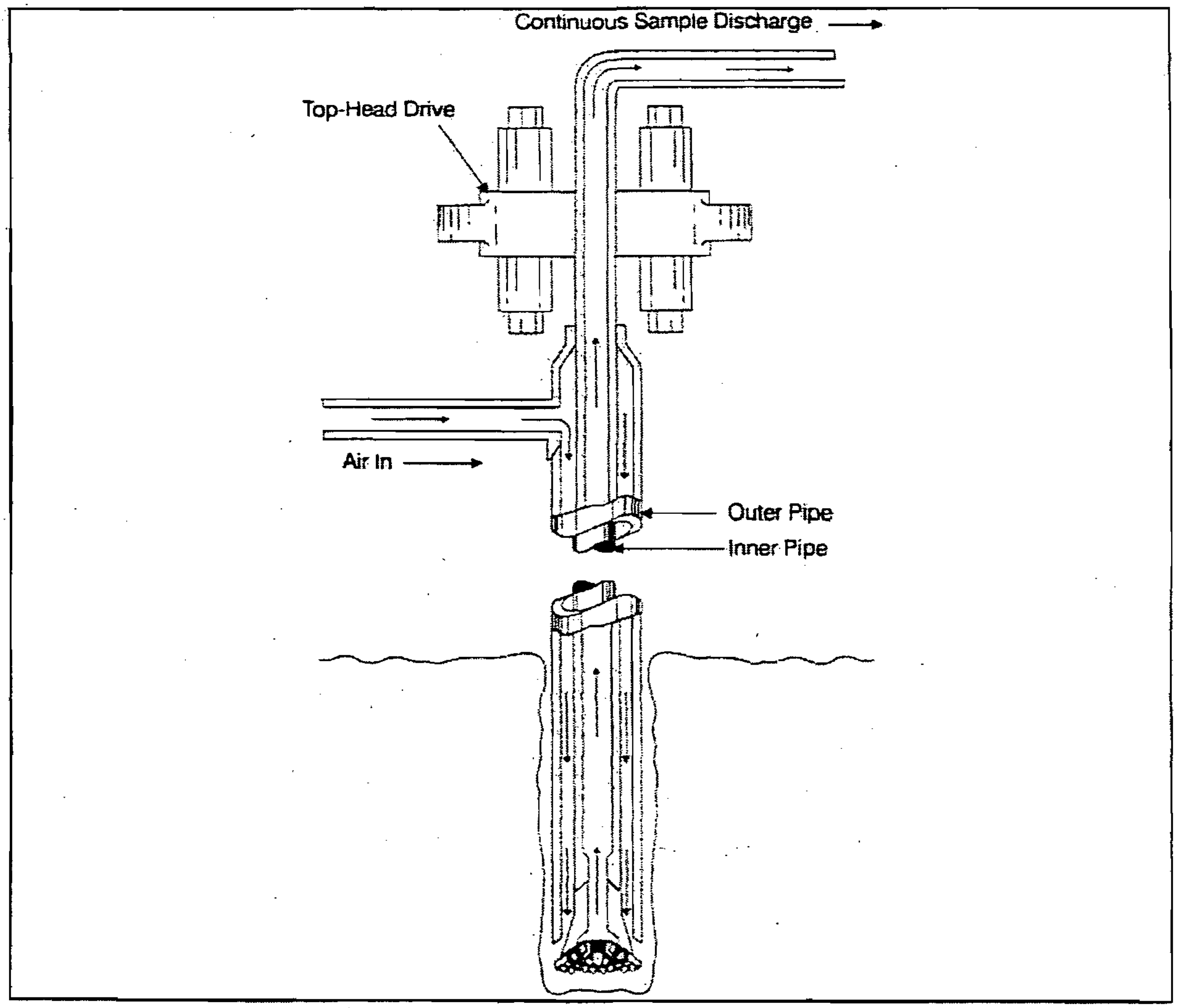

Figure 7 Reverse Circulation Rotary Method

6.7 Sonic Drilling

The sonic drill rig is similar to other drilling rigs in that it is a machine attached to a frame mounted on some type of vehicle. Sonic drilling is the use of high frequency vibration used in conjunction with down pressure and rotation to advance drilling tools through subsurface formations (see Figure 8). The use of high frequency vibration through the drilling tools causes the formation materials to vibrate at their natural frequencies allowing the drilling tool (casing) to advance by fracturing, shearing or displacing formation material. Most sonic drilling is utilized for drilling in unconsolidated material. However, sonic drilling can also be used for drilling and sampling of rock formations.

During drilling, unconsolidated samples are collected using a sample (or core) barrel. Core barrels are either solid tubes or split barrels of various diameters and lengths generally sized to match the inside diameter of the drill casing being utilized. Typical core barrels are 10 to 20 feet in length and casing sizes range from 0.5 inches to 12 inches, although 4 to 6 inch casing is typical. The core barrel is fitted with a drill bit/cutting shoe, and the sampler is placed within the outer casing material and attached to the rig by drilling rods. As the borehole is advanced, formation material is collected within the core barrel.

Following the sampling run (typically 10 to 20 feet), the core barrel is extracted from the well casing. Formation material is then extracted from the core barrel. Typically, sample material is extracted into a plastic sleeve, which is separated into convenient lengths for logging. The process of sonic drilling and sample collection will cause the sample to be distorted due to vibration, but generally will be intact. In the case of rock drilling, the vibration may create mechanical fractures that can affect the structural analysis for permeability and thereby not reflect the true *in-situ* condition.

The advantages to using sonic drilling technology includes reducing the amount of drill cutting generated, providing rapid formation penetration, and the recovery of a continuous core sample.

Physical Hazards

Noise. Excessive noise is generated from the use of oscillating drill head. Site personnel are required to wear hearing protection during drilling operations.

Overhead Equipment. During drilling operations steel casing (up to 20 foot lengths), core barrels, and drill rods may be hoisted in the air. Site personnel must conduct the necessary equipment inspections to ensure it is in good condition prior to the start of drilling operations. In addition, drillers must make sure that proper hoisting procedures are followed to reduce the likelihood of falling drill steel or sampling gear.

Slips/Falls. Site personnel can slip on wet ground around the drill rig or trip over drilling equipment (e.g. wrenches, etc.). Site personnel must keep the drilling location clear of debris and contain spillage prior to and during drilling operation.

Drill Rig Lurching. The drill rig may have a tendency to lurch and shake when the drill casing comes into contact with harder materials. Site personnel should be aware of possible drill rig movement and move away from the rig if lurching or shaking occurs.

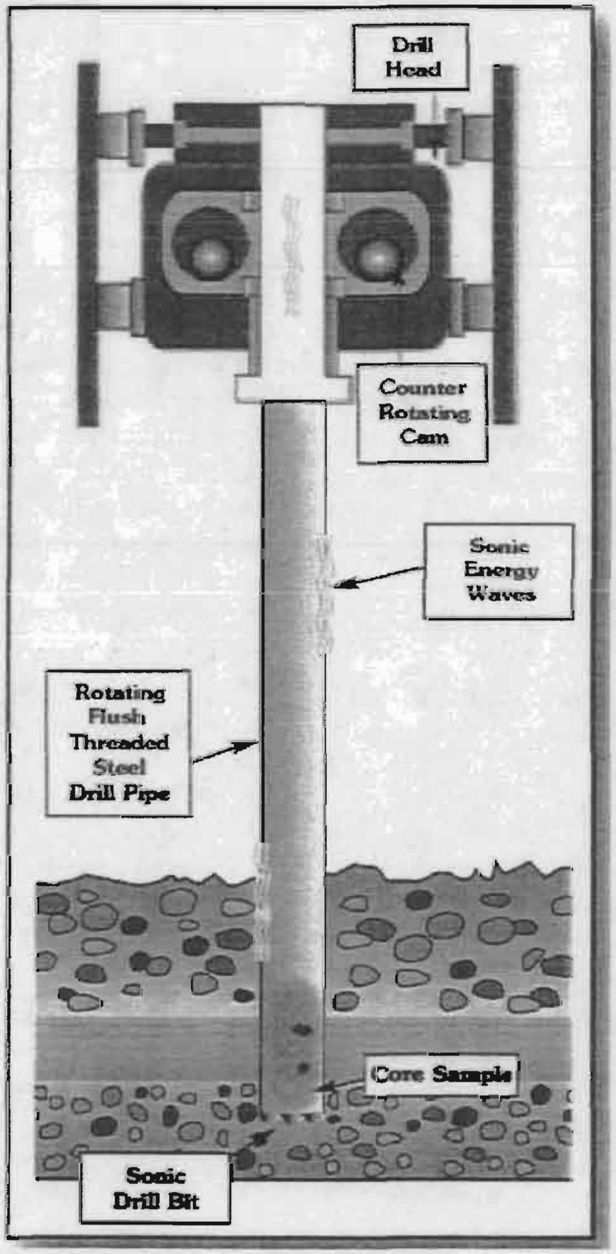

Figure 8 Sonic Drilling Method

Title:	SAMPLING EQUIPMENT DECONTAMINATION
Category:	ENV 3.15
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STANDARD OPERATING PROCEDURE

SAMPLING EQUIPMENT DECONTAMINATION

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1. Scope and Application

The purpose of this procedure is to provide a description of methods for preventing or reducing cross-contamination and general guidelines for designing and selecting decontamination procedures for use at potential hazardous waste sites. The decontamination procedures chosen will prevent introduction and cross-contamination of suspected contaminants in environmental samples, and will protect the health and safety of site personnel.

2. Method Summary

Removing or neutralizing contaminants that have accumulated on personnel and equipment ensures protection of personnel from permeating substances, reduces/eliminates transfer of contaminants to clean areas, prevents the mixing of incompatible substances, and minimizes the likelihood of sample contamination.

Cross-contamination can be removed by physical decontamination procedures. The abrasive and non-abrasive methods include the use of brushes, high pressure water, air and wet blasting, and high pressure Freon cleaning. These methods should be followed by a wash/rinse process using appropriate cleaning solutions. A general protocol for cleaning with solutions is as follows:

1. Physical removal.
2. Non-phosphate detergent plus tap water.
3. Tap water.
4. 10% nitric acid.
5. Distilled/deionized water rinse.
6. Solvent rinse.
7. Total air dry.
8. Triple rinse with distilled/deionized water.

This procedure can be expanded to include additional or alternate solvent rinses that will remove specified target compounds if required by site-specific work plans (WP) or as directed by a particular client.

3. Interferences

The use of distilled/deionized water commonly available from commercial vendors may be acceptable for decontamination of sampling equipment provided that it has been verified by laboratory analysis to be analyte-free distilled/deionized water. Distilled water available from local grocery stores and pharmacies is generally not acceptable for final decontamination rinses. Contaminant-free deionized water is available from commercial vendors and may be shipped directly to the site or your hotel.

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The use of an untreated potable water supply is not an acceptable substitute for tap water. Tap water may be used from any municipal water treatment system.

4. Equipment/Apparatus

The following are standard materials and equipment used as a part of the decontamination process:

- Appropriate protective clothing;
- Air purifying respirator (APR);
- Field log book;
- Non-phosphate detergent;
- Selected high purity, contaminant-free solvents;
- Long-handled brushes;
- Drop cloths (plastic sheeting);
- Trash containers;
- Paper towels;
- Galvanized tubs or equivalent (e.g., baby pools);
- Tap water;
- Contaminant-free distilled/deionized water;
- Metal/plastic container for storage and disposal of contaminated wash solutions;
- Pressurized sprayers, H_2O;
- Pressurized sprayers, solvents;
- Trash bags;
- Aluminum foil;
- Sample containers;

- Safety glasses or splash shield; and
- Emergency eyewash bottle.

5. Reagents

There are no reagents used in this procedure aside from decontamination solutions used for the equipment. The type of decontamination solution to be used shall depend upon the type and degree of contamination present and as specified in the project/site-specific Quality Assurance Project Plan (QAPP).

In general, the following solvents are utilized for decontamination purposes:

- 10% nitric acid wash (reagent grade nitric acid diluted with deionized/distilled water – 1 part acid to 10 parts water)[a];
- Acetone (pesticide grade)[b] ;
- Hexane (pesticide grade)[b];
- Methanol; and
- Methylene chloride[b].

[a] Only if sample is to be analyzed for trace metals.
[b] Only if sample is to be analyzed for organics requiring specific or specialized decontamination procedures. These solvents must be kept away from samples in order to avoid contamination by decon solvents.

6. Procedures

Decontamination is the process of removing or neutralizing contaminants that have accumulated on both personnel and equipment. Specific procedures in each case are designed accordingly and may be identified in either the Health and Safety Plan (HSP), WP, QAPP, or all three.

As part of the HSP, a personnel decontamination plan should be developed and set up before any personnel or equipment enters the areas of potential contamination. Decontamination procedures for equipment will be specified in the WP and the associated QAPP. These plans should include:

- Number and layout of decontamination stations;
- Decontamination equipment needed (see Section 4);

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- Appropriate decontamination methods;
- Procedures to prevent contamination of clean areas;
- Methods and procedures to minimize worker contact with contaminants during removal of protective clothing;
- Methods and procedures to prevent cross-contamination of samples and maintain sample integrity and sample custody; and
- Methods for disposal of contaminated clothing, equipment, and solutions.

Revisions to these plans may be necessary for health and safety when the types of protective clothing, site conditions, or on-site hazards are reassessed based on new information.

Prevention of Contamination

Several procedures can be established to minimize contact with waste and the potential for contamination. For example:

- Employing work practices that minimize contact with hazardous substances (e.g., avoid areas of obvious contamination, avoid touching potentially hazardous substances);
- Use of remote sampling, handling, and container-opening techniques;
- Covering monitoring and sampling equipment with plastic or other protective material;
- Use of disposable outer garments and disposable sampling equipment with proper containment of these disposable items;
- Use of disposable towels to clean the outer surfaces of sample bottles before and after sample collection; and
- Encasing the source of contaminants with plastic sheeting or overpacks.

Proper procedures for dressing prior to entrance into contaminated areas will minimize the potential for contaminants to bypass the protective clothing. Generally, all fasteners (zippers, buttons, snaps, etc.) should be used, gloves and boots tucked under or over sleeves and pant legs, and all junctures taped (see the Health and Safety Plan for these procedures).

Decontamination Methods

All personnel, samples, and equipment leaving the contaminated area of a site must be decontaminated to remove any chemicals or infectious organisms that may have adhered to them. Various decontamination methods will either physically remove, inactivate by chemical detoxification/disinfection/sterilization, or remove contaminants by both physical and chemical means.

In many cases, gross contamination can be removed by physical means. The physical decontamination techniques can be grouped into two categories: abrasive methods and non-abrasive methods.

6.1 Abrasive Cleaning Methods

Abrasive cleaning methods work by rubbing and wearing away the top layer of the surface containing the contaminant. The following reviews the available abrasive methods.

Mechanical

Mechanical methods include using brushes with metal, nylon, or natural bristles. The amount and type of contaminants removed will vary with the hardness of bristles, length of time brushing, and degree of brush contact. Material may also be removed by using appropriate tools to scrape, pry, or otherwise remove adhered materials.

Air Blasting

Air blasting equipment uses compressed air to force abrasive material through a nozzle at high velocities. The distance between nozzle and surface cleaned, air pressure, and time of air blasting dictate cleaning efficiency. The method's disadvantages are its inability to control the exact amount of material removed and its large amount of waste generated.

Wet Blasting

Wet blast cleaning involves the use of a suspended fine abrasive. The abrasive/water mixture is delivered by compressed air to the contaminated area. By using very fine abrasives, the amount of materials removed can be carefully controlled.

6.2 Non-abrasive Cleaning Methods

Non-abrasive cleaning methods work by either dissolution or by forcing the contaminant off a surface with pressure. In general, less of the equipment surface is removed using non-abrasive methods.

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High-Pressure Water

This method consists of a high-pressure pump, an operator controlled directional nozzle, and high-pressure hose. Operating pressure usually ranges from 340 to 680 psi, which relates to flow rates of 20 to 140 lpm.

Steam Cleaning

This method uses water delivered at high pressure and high temperature in order to remove accumulated solids and/or oils.

Ultra-High-Pressure Water

This system produces a water jet from 1,000 to 4,000 atm. This ultra-high-pressure spray can remove tightly-adhered surface films. The water velocity ranges from 500 m/sec. (1,000 atm) to 900 m/sec. (4,000 atm). Additives can be used to enhance the cleaning action, if approved by the QAPP for the project.

High-Pressure Freon Cleaning

Freon cleaning is a very effective method for cleaning cloth, rubber, plastic, and external/internal metal surfaces. Freon 113 (trichlorotriflorethane) is dense, chemically stable, relatively non-toxic, and leaves no residue. The vapor is easily removed from the air by activated charcoal. A high pressure (1,000 atm) jet of liquid Freon 113 is directed onto the surface to be cleaned. The Freon can be collected in a sump, filtered, and reused.

Physical removal of gross contamination should be followed by a wash/rinse process using cleaning solutions. One or more of the following methods utilize cleaning solutions.

Dissolving

Removal of surface contaminants can be accomplished by chemically dissolving them, although the solvent must be compatible with the equipment and protective clothing. Organic solvents include alcohols, ethers, ketones, aromatics, straight-chain alkanes, and common petroleum products. Halogenated solvents are generally incompatible with protective clothing and are toxic. Table 1 provides a general guide to the solubility of contaminant categories in four types of solvents.

Surfactants

Surfactants reduce adhesion forces between contaminants and the surface being cleaned and prevents reposition of the contaminants. Non-phosphate detergents dissolved in tap water is an acceptable surfactant solution.

Rinsing

Contaminants are removed and rinsing through dilution, physical attraction, and solubilization.

Disinfection/Sterilization

Disinfectants are a practical means of inactivating infectious agents. Unfortunately, standard sterilization methods are impractical for large equipment and personal protective clothing.

6.3 Field Sampling Equipment Cleaning Procedures

The following steps for equipment cleaning should be followed for general field sampling activities.

1. Physical removal (abrasive or non-abrasive methods).
2. Scrub with non-phosphate detergent plus tap water.
3. Tap water rinse.
4. 10% nitric acid (required during sampling for inorganics only).
5. Distilled/deionized water rinse.
6. Solvent rinse (required during sampling for organics only).
7. Total air dry (required during sampling for organics only).
8. Triple rinse with distilled/deionized water.

Table 1 lists solvent rinses which may be required for elimination of particular chemicals. After each solvent rinse, the equipment should be air-dried and triple-rinsed with distilled/deionized water.

Solvent rinses are not necessarily required when organics are not a contaminant of concern. Similarly, an acid rinse is not necessarily required if analysis does not include inorganics.

NOTE: Reference the appropriate analytical procedure for specific decontamination solutions required for adequate removal of the contaminants of concern.

Sampling equipment that requires the use of plastic or teflon tubing should be disassembled, cleaned, and the tubing replaced with clean tubing, if necessary, before commencement of sampling or between sampling locations.

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Table 1 Decontamination Solvents

Solvent	Soluble Contaminants
Water	Low-chain compounds Salts Some organic acids and other polar compounds
Dilute Bases For example: ■ detergent ■ soap	Acidic compounds Phenol Thiols Some nitro and sulfonic compounds
Organic Solvents: For example: ■ alcohols (methanol) ■ ethers ■ ketones ■ aromatics ■ straight-chain alkanes (e.g., hexane) ■ common petroleum products (e.g., fuel oil, kerosene)	Nonpolar compounds (e.g., some organic compounds)

WARNING: Some organic solvents can permeate and/or degrade the protective clothing.

7. Quality Assurance/Quality Control

QA/QC samples are intended to provide information concerning possible cross-contamination during collection, handling, preparation, and packing of samples from field locations for subsequent review and interpretation. A field blank (rinsate blank) provides an additional check on possible sources of contamination from ambient air and from sampling instruments used to collect and transfer samples into sample containers.

A field blank (rinsate blank) consists of a sample of analyte-free water passed through/over a precleaned/decontaminated sampling device and placed in a clean area to attempt to simulate a worst-case condition regarding ambient air contributions to sample contamination.

Field blanks should be collected at a rate of one per day per sample matrix even if samples are not shipped that day. The field blanks should return to the lab with the trip blanks originally sent to the field and be packed with their associated matrix.

The field blank places a mechanism of control on equipment decontamination, sample handling, storage, and shipment procedures. It is also indicative of ambient conditions and/or equipment conditions that may affect the quality of the samples.

Holding times for field blanks analyzed by CLP methods begin when the blank is received in the laboratory (as documented on the chain of parameters and associated analytical methods).

Holding times for samples and blanks analyzed by SW-846 or the 600 and 500 series begins at the time of sample collection.

8. Health and Safety

Decontamination can pose hazards under certain circumstances even though performed to protect health and safety. Hazardous substances may be incompatible with decontamination methods (i.e., the method may react with contaminants to produce heat, explosion, or toxic products). Decontamination methods may be incompatible with clothing or equipment (e.g., some solvents can permeate and/or degrade protective clothing). Also, a direct health hazard to workers can be posed from chemical decontamination solutions that may be hazardous if inhaled or may be flammable.

The decontamination solutions must be determined to be compatible before use. Any method that permeates, degrades, or damages personal protective equipment should not be used. If decontamination methods do pose a direct health hazard, measures should be taken to protect personnel or modified to eliminate the hazard.

All site-specific safety procedures should be followed for the cleaning operation. At a minimum, the following precautions should be taken:

1. Safety glasses with splash shields or goggles, neoprene gloves, and laboratory apron should be worn.

2. All solvent rinsing operations should be conducted under a fume hood or in open air.

3. No eating, smoking, drinking, chewing, or any hand-to-mouth contact is permitted.

9. References

Field Sampling Procedures Manual, New Jersey Department of Environmental Protection, 1988.

A Compendium of Superfund Field Operations Methods, EPA 540/p-87/001.

Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual, USEPA Region IV, April 1, 1986.

Occupational Safety and Health Guidance Manual for Hazardous Waste Site Activities, NIOSH/OSHA/USCG/EPA, October 1985.